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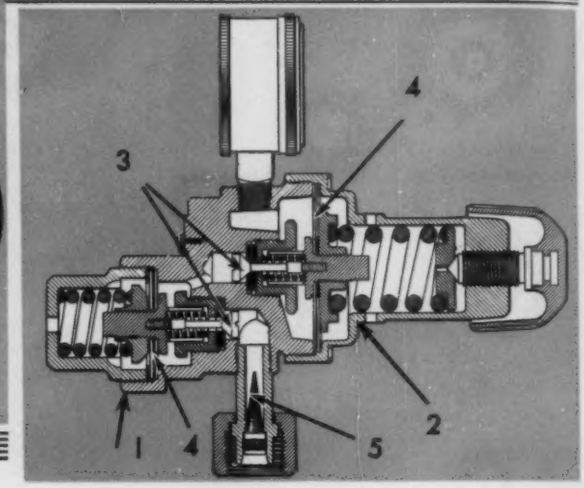

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JUNE

Contents

Technical Papers, Items and Reports

Page

Condenser Fabricated by Gas Welding (Courtesy Union Carbide Company)..Frontispiece
Some Recent Applications of Welding, by *A. F. Davis*..... 2
Home Heating Modernization, by *Owen C. Jones*..... 8
Repair of Broken 2500-Pound Gear Wheel, by *W. T. Cook*..... 9
Electric Welding in Japan, by *Minoru Okada*..... 10
Spring Grove State Hospital Auditorium Building, by *Van Rensselaer P. Saxe*..... 16
Magnetic Characteristics of Metal Deposited by the Oxyacetylene Welding Process, by *Wendell F. Hess* and *Robert Lee Ringer, Jr.*..... 18
Flame-Shaping Flywheels, by *W. D. Wilkinson, Jr.*..... 21
The Design of Welded Seat Angle Connections—Flexible Type, by *Heath Lawson*.. 23
Current Welding Literature..... 25

Society and Related Activities

Amendments to By-Laws of American Welding Society..... 26
Correction to Article Published in the April Issue of the Journal..... 26
Kansas Welding Conference..... 27
New Member Board of Directors..... 27
Turner C. Smith..... 27
Errata..... 27
International Competition for the Development of Uses of Calcium Carbide and Acetylene..... 27
Fundamental Welding Researches—The Quality of Steel Most Suitable for Arc Welding, by *G. E. Doan*..... 27
Employment Service Bulletin..... 28
Section Activities..... 28

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Some Recent Applications of Welding

By A. F. Davis†

Boston Sloop Yankee to Invade Britain with New Arc-Welded Steel Mast

The 126-foot Boston sloop *Yankee*, scheduled to invade British racing waters this summer, thrilled many a yacht racing enthusiast recently when she satisfactorily tested her new racing rig in a sail-stretching run off Neponset, Mass.

Skippered by her owner, Commodore Gerard Lambert of the Eastern Yacht Club, the *Yankee* bowled down Presidents' Road at 11 knots with a smother of foam along her weather rail and her 165-foot welded steel mast appearing as a silver needle against the murky clouds.

On board with her owner were Charles Francis Adams, former secretary of the Navy and the *Yankee's* skipper in her 1930 and 1934 America's cup trials, Frank C. Paine, the *Yankee's* designer, Gus Olsen and Capt. John Christensen, veteran sailing masters, and her expert crews.

The *Yankee's* steel mast, first of its kind ever turned out in America, was made by Geo. Lawley & Sons Co., Neponset, Mass., entirely of arc-welded nickel steel. In the face of a 12-knot southeast blow, this mast showed no sign of whipping.

The total length of the mast is 165 feet 7 inches, diameter 18 inches at the bottom tapering to 7 inches at the top. Thickness at the bottom is $^{3}/_{16}$ inch, at the top

† Vice-President, The Lincoln Electric Company.

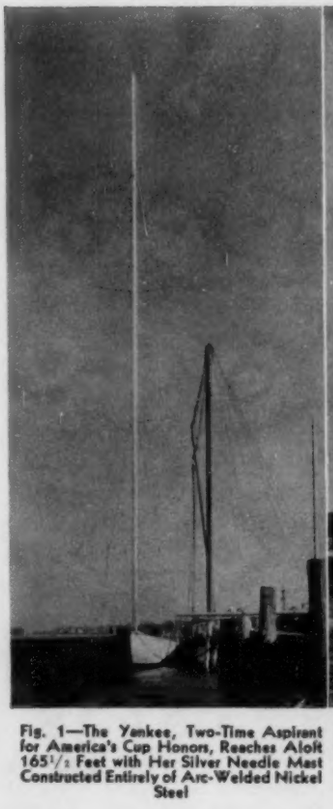


Fig. 1—The Yankee, Two-Time Aspirant for America's Cup Honors, Reaches Aloft 165½ Feet with Her Silver Needle Mast Constructed Entirely of Arc-Welded Nickel Steel

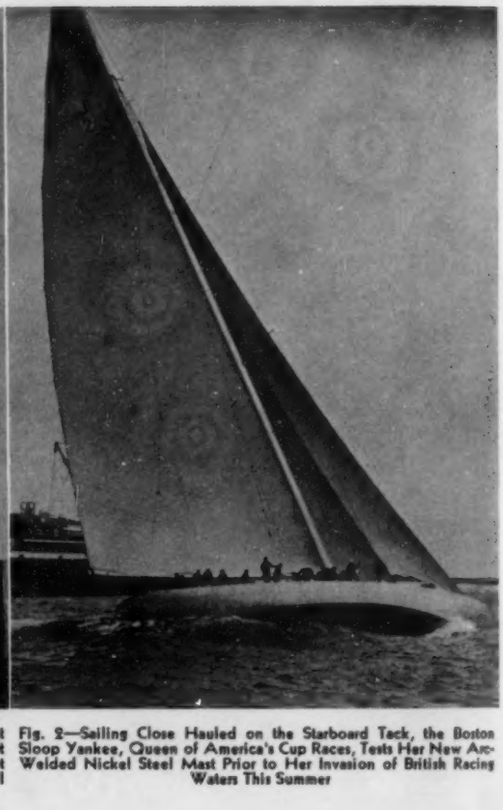


Fig. 2—Sailing Close Hauled on the Starboard Tack, the Boston Sloop Yankee, Queen of America's Cup Races, Tests Her New Arc-Welded Nickel Steel Mast Prior to Her Invasion of British Racing Waters This Summer

Fig. 3—Welded by the Shielded Arc Process, This Nickel Steel Mast for the Boston Sloop Yankee Weighs 500 Pounds Less Than the Wooden Mast with Which She Was Formerly Fitted

Fig. 4—All Welding on the Yankee's 165½ Foot Nickel Steel Mast Was Done with a Special Electrode Which Provides Welds with a Tensile Strength of 85,000 to 100,000 Pounds per Square Inch

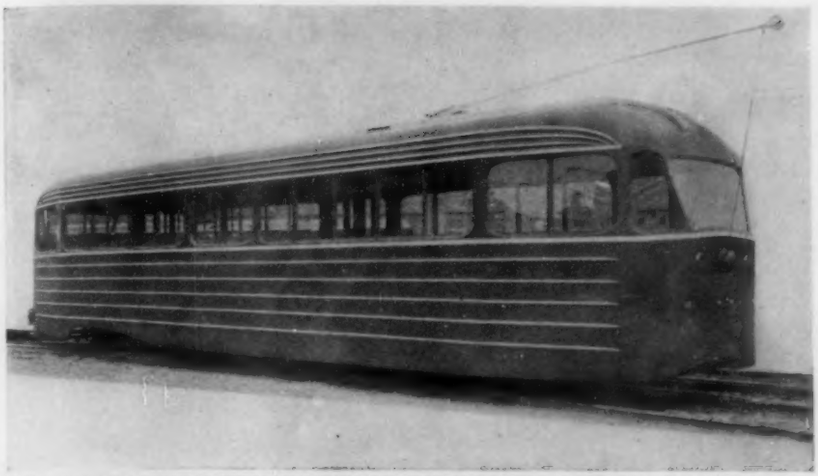


Fig. 5—New Trolley Car, Constructed by Arc Welding in the Chicago Shops of the Pullman Car & Mfg. Company for the Electric Railway Presidents' Conference Committee, Weighs a Third Less Than Conventional Trolleys, Accelerates Twice as Fast and Is Virtually Noiseless in Operation

1/8 inch. The weight is approximately 5700 pounds, compared with 6200 pounds for the former wooden mast which carried the *Yankee's* rigging in the 1934 America's cup trials. Besides saving 500 pounds in the weight of her mast, the *Yankee* also saves 320 square feet of windage. This is equivalent to the sail area of a 30-square meter or 42-foot racing sloop.

The mast, which is hollow, was built in four sections. Each section was made from a single sheet of steel, rolled to cylindrical shape with edges butted together and welded the entire length. When all four sections were completed they were welded together with a steel ring at the joint. All stays and other rigging fixtures were then welded in proper position on the mast. The 450 feet of welding required on the mast was done with a special electrode which provides welds of 85,000 to 100,000 pounds per square inch tensile strength in high tensile steels.

Stepping the *Yankee's* steel mast was a delicate job. It required over 50 men and a floating derrick. A 50-foot timber lashed to the mast relieved the strain placed on it during handling. The derrick then picked up the mast and swung it into place. Finally, by use of capstan bars, it was twisted into proper position.

During the summer, the *Yankee* will meet the *Endeavour*, *Shamrock V* and the King's own veteran cutter *Brittania*. Charles Francis Adams, former secretary of the Navy, will again be her skipper on most of her races with the English "big stickers."

New Street Car of Arc-Welded Alloyed Steel Construction Is Light, Fast and Quiet in Operation

Now the lowly street car has gone modern.

A new street car, as revolutionary in its field as the high speed streamlined railroad train is in its, has been developed after four years of intensive research by the Electric Railway Presidents' Conference Committee.

Not only does this new car weigh 10,000 to 20,000 pounds less than conventional types, it accelerates twice as fast and is practically noiseless in operation. These amazing results have been made possible by following the most modern principles of design and by utilizing the latest developments in manufacturing materials and processes, including a new low weight high tensile steel and the electric arc process of welding.

In appearance (see Fig. 5) the new arc-welded trolley car presents a form and lines with a pronounced appeal to an automotive-minded public. Drab rectangular windows have been eliminated. Hard straight lines have given way to smooth flowing contours and streamlining effects.

The Plan Behind the Car

In planning this car, the committee went to the car riding public for ideas. The passenger's comfort formed the nucleus around which the car was built. Requirements of modern traffic conditions for quick starting and stopping were govern-

Fig. 6—The Body of This New Trolley Car Is Constructed Throughout by Arc Welding. Sheeting of Low Weight High Tensile Steel Bent, Pressed and Formed into a Number of Properly Shaped Parts, Is Used Directly into Framing Made of the Same Material

Fig. 7—A Ride in This Arc-Welded Street Car Is a New Experience. Gone Are the Jerks and Jolts, the Slow Lumbering Gait and the Nerve-Jarring Noise Always Associated with Conventional Street Cars

ing factors. The requirements, as determined by the committee, were as follows:

1. Elimination of noise and all disagreeable vibration.
2. Body structures having maximum strength and rigidity consistent with minimum weight and construction cost.
3. Motor and control equipment which would provide a degree of agility comparable with that of modern automobiles and which would permit high acceleration rates to be achieved so smoothly as to avoid discomfort to standing passengers.
4. Braking equipment which would permit high schedule speeds to be obtained with adequate safety in congested traffic.
5. Simplicity in the operation of control and brakes.
6. Attractive exterior and interior body design combined with modern seating, illumination, heating and ventilation.

New Steel Used in Construction

The body of the trolley (see Fig. 6) is constructed of a new low-chromium alloy steel which provides light weight with high tensile strength and resistance to corrosion. This steel was supplied in sheets bent, pressed and formed into a number of properly shaped parts which were welded together into one single continuous structure by the electric arc. Arc welding is used throughout in frame and sheeting.

The entire framing structure presents radical departures from conventional car practice and is intended to provide a design capable of cheap and rapid fabrication, while, at the same time, yielding a permanently tight rigid construction.

General particulars of the car are as follows:

Length, over-all	45 ft. $3^{3}/_{16}$ in.
Width, over-all	8 ft. $4^{7}/_{8}$ in.
Height, rail to top of roof	10 ft. $3^{5}/_{8}$ in.
Total weight of car	32,200 pounds
Weight of car body	16,800 pounds
Weight of trucks	15,400 pounds
Number passenger seats	47

Trucks Welded of Tubular Steel

The truck framing is of arc-welded tubular steel construction. The springs of the trucks are made entirely of rubber. Wheels are of a special design developed by the committee. They are made of steel parts so interlocked with rubber as to give the desired cushioning and at the same time to provide adequate strength and long life.

Particulars of Trolley Tracks

Truck wheel base	6 ft. 0 in.
Wheel diameter	2 ft. 0 in.
Gear ratio	6.83 to 1
Truck weight, pounds	7300

Maximum acceleration is 4.75 miles per hour per sec.

Maximum deceleration is in excess of 8 miles per hour per sec.

Three Types of Brakes Used

The car is equipped with eddy current brakes, magnetic track brakes and hydraulically operated drum brakes. The three types of brakes are controlled from one pedal and operate sequentially as determined by the extent the pedal is depressed. With this arrangement, the operator need give no attention to which brake is operated at any given moment. A hand brake is also provided for operation on the front truck.

In order to keep weight at a minimum, equipment supports and boxes, as well as under-floor ducts for wiring and other purposes are incorporated as part of the floor framing.

This car was built by the Pullman Car and Manufacturing Corporation, Chicago, Illinois, using "Cor-Ten" steel manufactured by the United States Steel Corpn.

The Electric Railway Presidents' Conference Committee, under whose auspices this car was built, consists of the chief executive officers of some 25 of the larger urban transit companies of the United States and Canada.

The construction of the sample new type trolley car is the outgrowth of more than four years of research and development work under the auspices of this Committee. The new features of the car have been tested both in the laboratory and in practice to a sufficient extent to show that they represent practical developments. However, as in the case of all new things, there remain small troubles to be overcome and certain manufacturing and economic problems to be worked out before trolley companies generally will be in a position to utilize this new type equipment. The difficult financial position in which most urban transportation properties have found themselves for the past decade presents to them the difficult financial problem of finding means for the introduction of cars of this new type. Nevertheless the Committee and the transit industry have been able to carry on the intensive work of development throughout the depression years on the assumption that if a sufficient improvement could be achieved ways and means would ultimately be found for financing the purchase of cars of this type.

The chairman of the committee is Dr. Thomas Conway, Jr., president of the Philadelphia & Western Railroad. Dr. C. F. Hirshfield of Detroit, internationally known research expert, is chief engineer. John Hession, Jr., well known automotive designer, developed the general architectural design in conjunction with the committee.

Fig. 8—A Welded Propane Tank, 67 Feet Long by 8 Feet 10 Inches Diameter, Built by The Biggs Boiler Works Company, Akron, Ohio, in Accordance with A. S. M. E. Code Requirements for Welded Construction. All Welding Was Done by the Shielded Arc Process

Arc-Welded Propane Tank Built of New High Tensile Steel

Three thousand six hundred cubic feet is a lot of propane gas to store at 200 pounds per square inch pressure!

Forty-one tons of a new steel, which has a tensile strength of 70,000 to 82,000 pounds per square inch, were used recently in fabricating a propane tank of this capacity at the plant of The Biggs Boiler Works Company, Akron, Ohio. This tank, 67 feet long by 8 feet 10 inches diameter, was built by the shielded arc process of welding in accordance with requirements of the A. S. M. E. Code for unfired welded pressure vessel construction. According to the manufacturer, arc welding was used to insure absolutely leak-proof construction.

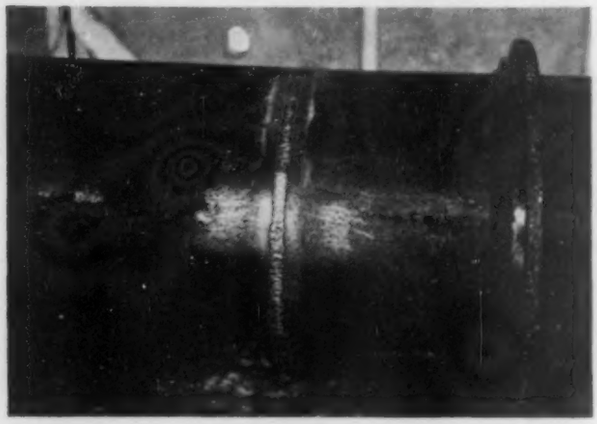
The steel used in constructing this tank is a special high tensile carbon steel developed for pressure vessels. It is made two inches and under in thickness. The analysis of the steel shows 0.32 carbon, maximum, for plate $^{3}/_{4}$ inch and less in thickness, and 0.35 carbon, maximum, for thicknesses over $^{3}/_{4}$ inch; 0.90 manganese; 0.035 to 0.04 phosphorus; 0.04 to 0.05 sulphur; and 0.25 silicon. The yield point, minimum, is one half the tensile strength.

All seams of the tank were butt welded under the special procedure control developed by the builder. The large heads are one piece construction $1^{5}/_{16}$ inches thick.

This tank, shown in the accompanying illustration, operates at a working pressure of 200 pounds per square inch and passed a hydrostatic pressure and hammer test of 400 pounds. It was inspected and stamped for Code requirements by the Hartford Steam Boiler Inspection and Insurance Company. The high tensile strength necessary in welding this steel was provided by use of shielded arc welding.

Fig. 9 (Left)—Salt Evaporator

Fig. 11 (Lower)—A Completed Butt Joint after the Second Bead Has Been Laid Flush with Pipe Edges on New Cleveland Arc-Welded Gas Pipe Line



Salt Evaporator

To provide salt for America's breakfast table, this 25-ton evaporator was designed and completed for one of the largest salt manufacturers. In it wet salt is stirred up by a bronze propeller, circulated through 828 copper tubes, distilling off the water. (Fig. 9.)

This giant salt maker, designed by Clinton S. Robinson & Associates, Chicago, is about 50 feet long, 12 feet in diameter at its widest point. It was built by Wellman Engineering Company, Cleveland, Ohio, entirely by shielded arc welding. Arc-welded steel, replacing cast iron, saves approximately 50% of the weight, materially reduces the cost, and builds a stronger job. Proof of strength: A crane yanked the evaporator by the neck from prone position, stood it on end.

Arc Welding Used in Construction of Large Gas Pipe Line

A new gas pipe line, over 3000 feet in length and built of 20 inch pipe with all field joints arc welded, was recently completed over one of Cleveland's longest bridges. The East Ohio Gas Company, for whom the line was constructed, specified welding as a safety factor. The new line hooks into existing services at either end of the bridge.

This line is constructed of 40 foot pipe, factory welded from 20 foot lengths. The pipe is $^3/_8$-inch wall thickness, 20 inches diameter with ends beveled to 45 degrees. Total weight of pipe used over the bridge was 126 tons. The total length of the line from one end of the bridge to the other is 3017 feet.

The line was strung on the paved roadway of the third level of the bridge. In order to get the pipe up on this level it was necessary to hoist it with chain falls onto a small truck, which hauled it to position. The truck was fitted with a dolly which facilitated the placing of the pipe.

The pipe was mounted on roll and saddle mountings (see Fig. 10) permanently bolted to the beams of the bridge. The pipe was lined up, with a space of $^1/_8$ inch between joints. After the pipe was in proper position and blocked up, five tack welds were made on the joint to hold it in place for starting to weld. Plain butt joints without backing up rings were used. Two beads were run per joint, except where the opening between the pipe ends exceeded $^1/_8$ inch, in which case a sealing bead was used. One bead was laid clear around the joint and nearly flush with the pipe. The second bead was laid to make a flush weld. (See Fig. 11.) In making the first few welds, it was

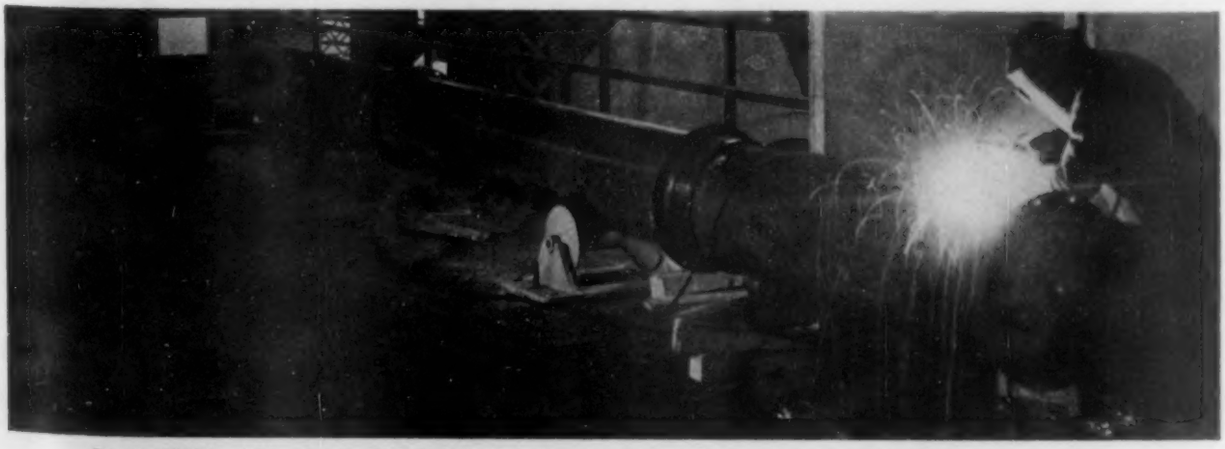
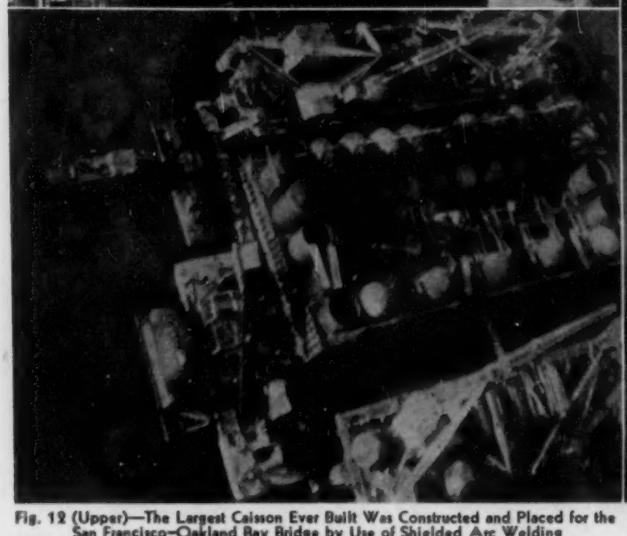


Fig. 10—Welding a Joint on the New 3017-Foot 20-Inch Gas Pipe Line in Cleveland, Said to Be the Largest Gas Line Ever Strung over a Bridge



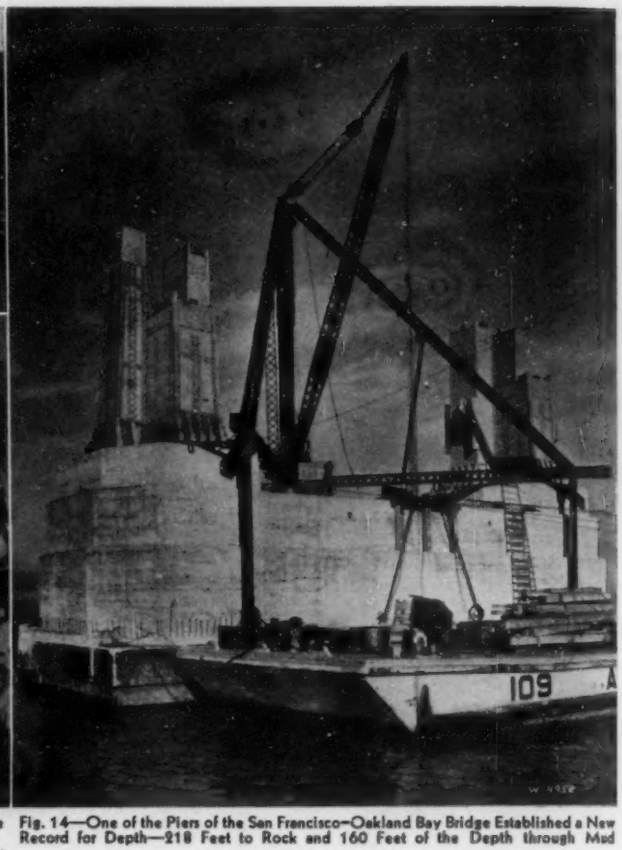


Fig. 12 (Upper)—The Largest Caisson Ever Built Was Constructed and Placed for the San Francisco–Oakland Bay Bridge by Use of Shielded Arc Welding

Fig. 13 (Lower)—Airplane View of Caisson Towed to Site. This and Similar Caissons Were Sunk in Water up to 105 Feet in Depth and Carried Down from 40 to 160 Feet Further, through Mud to Rock

Fig. 14—One of the Piers of the San Francisco–Oakland Bay Bridge Established a New Record for Depth—218 Feet to Rock and 160 Feet of the Depth through Mud

possible to roll the pipe, but after four lengths of pipe has been welded, the remaining joints had to be welded without turning the pipe. A total of 89 joints were welded. Each joint required approximately four pounds of $^{3}/_{16}$ inch electrode.

A total of eight expansion joints of the slip type were used on the line. The slips of these expansions were made of stainless steel to prevent corrosion. Each slip can move a maximum of eight inches. Six of these were single and two double, the latter placed at the apex of the bridge. The pipe was welded to the nipples of the expansion joints. After welding, all joints were annealed. Approximately 30 days were required for laying and welding the pipe.

The welding current was supplied by one of the new 300 ampere gasoline engine arc welders. This welder was equipped with a time-delay idling device which slowed down the engine approximately 30 seconds after the arc was broken, insuring maximum fuel economy while still permitting the welding operator to change electrodes without affecting welding current. According to the welding foreman on this job, this idling device made a difference of one gallon per hour in fuel consumption.

When completed, the line was tested with 85 pounds pressure. In operation the line will carry a pressure of approximately 40 pounds. Regarding the effects of temperature variations it was found that the line expands or contracts at the rate of 0.2 inch per degree change in temperature.

Arc Welding Speeds Construction of World's Largest Bridge

San Francisco's dream of a bridge spanning the water barrier between it and communities on the east side of the bay, is rapidly becoming a reality as construction progresses on the $77,000,000 San Francisco–Oakland Bay Bridge. This bridge, which is over $8^{1}/_{2}$ miles long including approaches, contains one of the longest cantilever spans in the world. This single span over the ship channel is 1400 feet in length and suspended for 576 feet of its length. Only the Quebec bridge and that over the Firth of Forth are longer.

Construction of the San Francisco–Oakland Bay Bridge, ground for which was broken July 9, 1933, when President Roosevelt pressed a telegraphic key in the White House at Washington, has proceeded rapidly considering the size of the undertaking. Today, the work has progressed to the point that preparations are being made to begin stringing the cable.

Two of the most modern engineering developments, both made possible by shielded arc welding, are speeding construction of this bridge. One of these is a specially constructed caisson of compressed air flotation type for anchoring the piers; the other a giant wire-spinning wheel for spinning the cable.

The caissons—seven of which were required—were all built of arc-welded steel by the Moore Dry Docks Company at their Oakland yard. The largest caisson, that for the west Pier No. 4 (see Fig. 12) is 197 feet long by 92 feet wide and has an arc-welded steel cutting edge $17^{1}/_{2}$ feet deep.

Fifty-five holes, square below and cylindrical above the cutting edge, were capped with an arc-welded steel dome. The caisson was built up to a height of $77^{1}/_{2}$ feet, made buoyant by air trapped and compressed in the cylinders and towed to its site. (See Fig. 13.)

When in position, concrete was poured between the cylinders and outside wall of the caisson. Then the operation of alternately building up and sinking down began.

The height was increased by burning off the domes, arc welding on 20 foot extensions and welding the domes back in place. This process was repeated over and over again until the cutting edge rested in mud. From there on down to rock bottom the caisson was submerged by removing the domes and dredging through the 55 wells.

This same procedure was used on all pier construction. In one instance it was necessary to sink the caisson 218 feet, 160 feet of the depth through mud. Over 400,000 lineal feet of welding was required on the caissons. Fig. 14 shows a pier with steel towers in place.

The wire spinning wheels, over 100 of which have been built for spinning cable on this bridge, are also entirely of arc welded steel construction. Built by the R. B. Hayward Company, Chicago, these wheels (see Fig. 15) are 94 inches in diam-

Fig. 15—Constructing a 94-Inch Diameter Spinning Wheel by the Shielded Arc Process of Welding for Use in Spinning Cable on the San Francisco–Oakland Bay Bridge. Shielded Arc Welding Permitted 33% Faster Construction Than Former Method

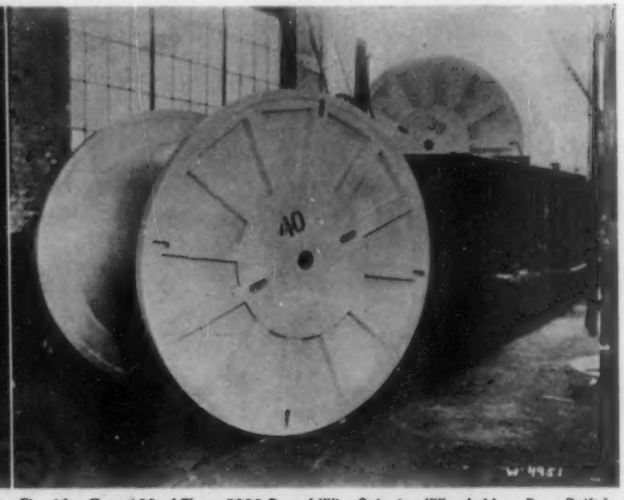


Fig. 16—Over 100 of These 5000-Pound Wire Spinning Wheels Have Been Built by Shielded Arc Welding for the San Francisco–Oakland Bay Bridge. One Unit, Like This One Shown, Carries 16 Tons of $^{3}/_{16}$-Inch Steel Wire

eter, 4 inches thick and weigh approximately 5000 lb. completely assembled. They are built of 8 and 10 gauge steel welded by the shielded arc process. Each wheel will carry 16 tons of $^{3}/_{16}$ inch steel wire.

Six of these spinning wheel units, consisting of two wheels and drum (see Fig. 16), are used on one huge cable spinning machine which can turn out over 80 tons of wire rope in a single length without reloading. A single $8^{1}/_{2}$ mile length of $1^{1}/_{2}$ inch wire rope, such as could be produced by this machine at one loading, would contain over 2500 miles of steel wire.

World's Largest D.C. Fan Cooled Motor Constructed by Arc Welding

The world's largest direct current fully enclosed fan cooled motor was recently completed in Cleveland, according to the Reliance Electric & Engineering Company, manufacturers. Arc-welded construction was employed because it provides a neater finished appearance, higher ductility and

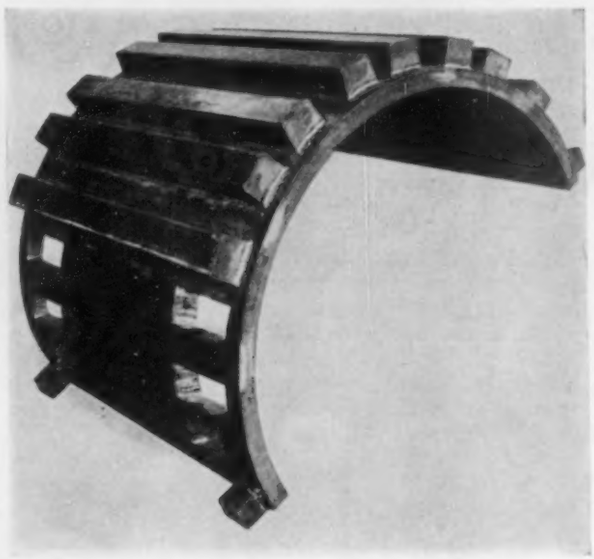


Fig. 17—Half of the Frame After Channels Have Been Welded in Place. These Channels Cool the Motor and Are Welded All the Way Around to Provide Air-Tight Construction

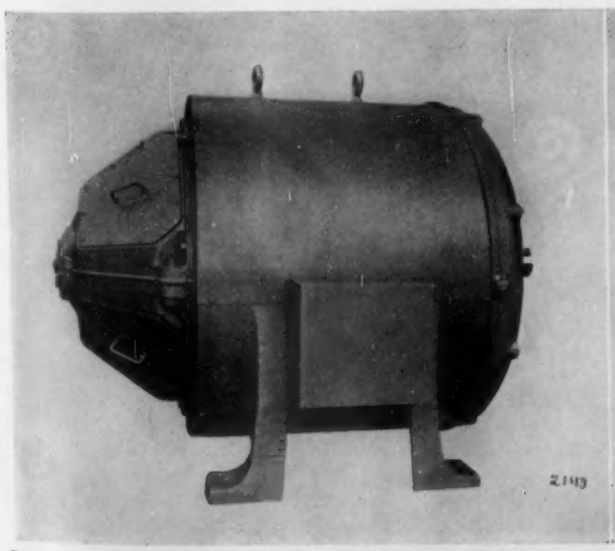


Fig. 18—World's Largest Direct Current, Fan Cooled Motor, Rated 200 Horsepower at 400 R.P.M. and Built by the Shielded Arc Process of Welding. Total Weight Is 14,000 Pounds

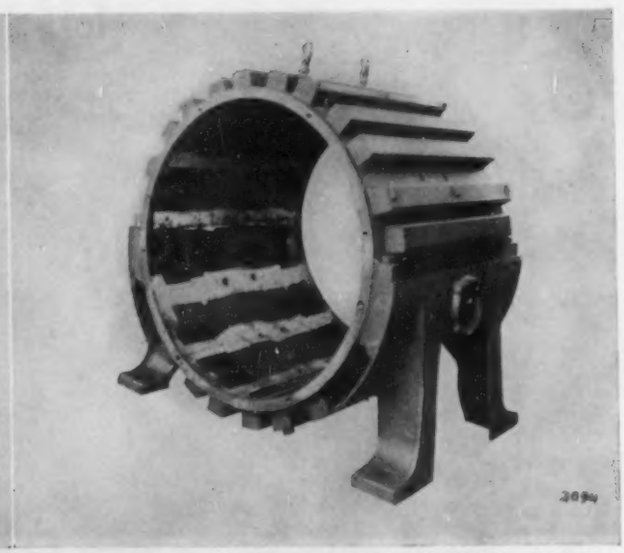


Fig. 19—Completed Frame Machined Ready to Receive Field Coils. All Channels Have Been Welded in Place on the Frame and the Cast Steel Legs Have Been Welded to the Frame

greater strength. The manufacturer also reports lower costs of construction with arc welding.

This large motor (see Fig. 18) is 7 feet, 6 inches long and weighs 14,000 pounds. It is rated at 125 horsepower at 300 revolutions per minute and is to be used to operate a steel mill pickling machine. Two hundred horsepower can be secured if the motor is wound for 400 r.p.m.

The frame of this motor is made of 2 inch rolled steel, cut and formed into two semi-circular sections, with holes punched for the channels. The channels, made of 1/4 inch steel plate, are then welded to the frame as shown in Fig. 17. These channels are welded all the way around, making them air-tight. Besides keeping dirt away from the windings, the channels provide a means of cooling the motor. The air inside the motor circulates through these channels and an outer fan blows cooling air over the external surfaces.

The motor is supported on two sets of cast steel feet welded directly to the motor frame. Fig. 19 shows the completed frame after it has been machined, ready for receiving the field coils and with the cast steel feet welded in place.

Home Heating Modernization

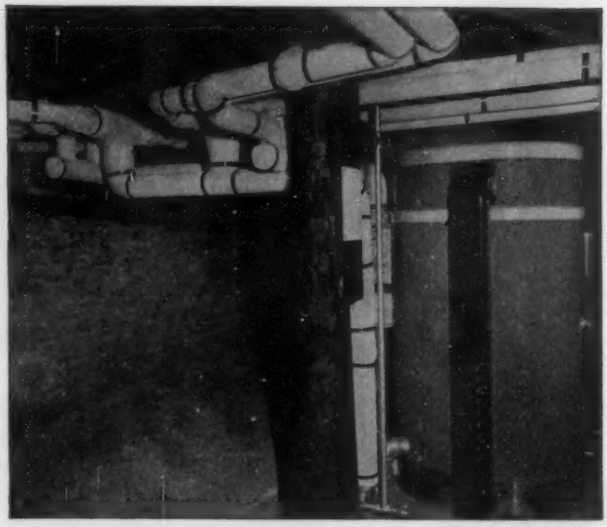
By OWEN C. JONES†

Welding Makes Installation of Modern Domestic Heating Units an Easy Job

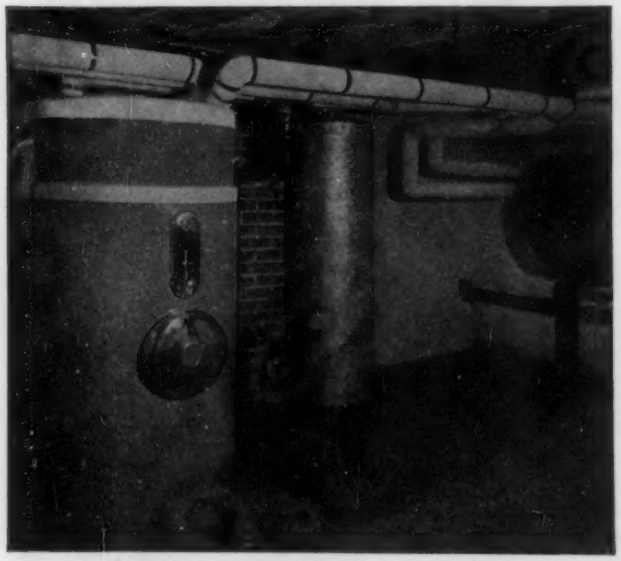
WITH the recent emphasis and cooperation that has been given building and modernization activities by the various Federal agencies during the past few months, it is reasonable to expect an increase in demand for the installation of modern domestic heating units. The design and features of some of the more modern small heating units are such that wide sales opportunities are open to heating and air-conditioning contractors. Experience has already shown that the use of the oxyacetylene welding process for the installation work means a further inducement toward the purchase of such heating units.

In connection with the installation of such units, there is the growing desire of the average homeowner to be able to use his basement for more than just a furnace and storage room. He realizes more and more that the space heretofore required for a large furnace, a labyrinth of piping, bins for fuel, ash cans and similar annoyances can be utilized very nicely for recreation space, a workshop or other purposes that make life more pleasant.

† Technical Publicity Department, The Linde Air Products Company.



Installation of New Furnace Would Have Been Almost Impossible Had Not Oxyacetylene Welding Been Available for Easy Alteration of the Piping System



A Modern Furnace Installed by Modern Methods Means More Usable Space and Less Expense

This holds true whether or not the owner or builder is building a new house or merely renovating an existing structure. There is no getting away from the fact that a new compact heating unit, of itself, is a desirable thing to have in the home. But often this inducement alone will not make a sale. The elimination of unsightly groupings of pipe made possible through a welded installation will go a long way toward convincing the homeowner that he can finish off his basement rooms to make them livable and usable.

In connection with the modernization of older dwellings, the expense of the modernization work can be considerably cut down by the use of welded piping. To rip out an old furnace with its incidental fixtures and place a new modern unit in its place entails considerable work on the existing piping system. Here again a great deal of work can be eliminated, and a much better appearing room will result if the oxyacetylene process is used.

One prominent plumbing and heating contractor in the

East is particularly well pleased with the savings in labor and material made possible by the use of the oxyacetylene process in connection with the installation of a certain type of modern oil furnace. His enthusiasm, in fact, caused him to mail in some photographs of various installations to show what is being done along these lines.

He states that he has been able to reduce his labor costs 50 per cent. The finished jobs have a fine appearance, most pleasing to the owners. This firm has standardized on using the oxyacetylene welded installation idea as the first factor or inducement in the sales presentation. This is particularly true when the change-over will take place in cold weather. Prospects are quickly convinced of how rapidly an installation can be made, as well as of the superiority of the welded construction.

This sort of enthusiasm, resulting as it did in an unsolicited expression of opinion, seems to point out that this welding feature should not be overlooked by others who plan to compaign along the same line.

There are certain other points that add considerably to the sales possibilities of this idea. It was found in a great many cases that it would have been practically impossible to make a change-over to the more modern heating unit without the use of welding. The fact that the work can be done for considerably less than it would cost by other methods, offers a further incentive to the homeowner.

With these facts standing behind the idea, dealers offering modern furnaces should have little trouble convincing new prospects that the time is ripe for a change-over from the old to the new. All of the arguments advanced in favor of the use of these new types of heating units can be amplified and emphasized if the dealer himself is in a position to offer a fast, neat, economical welded job. Opportunities such as this are too valuable to be overlooked, and every dealer who handles these new types of furnaces should investigate the possibilities immediately.

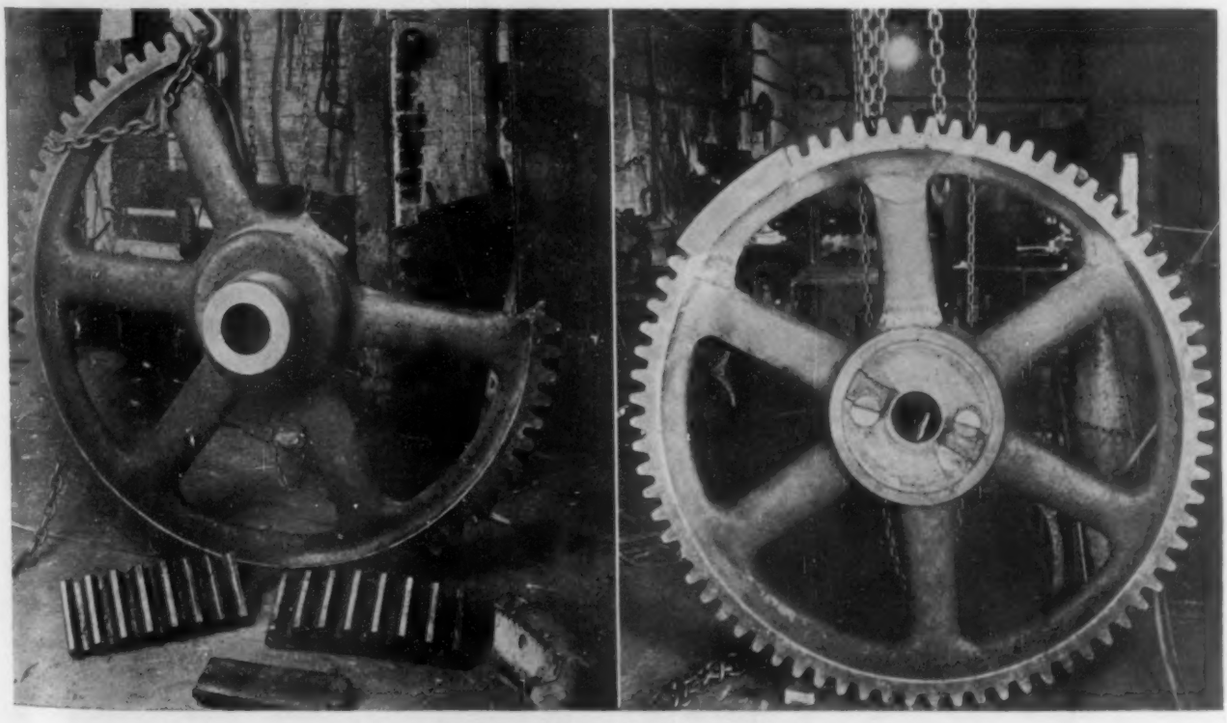
Repair of Broken 2500-Pound Gear Wheel

By W. T. COOK†

A SPOKED gear wheel, seven feet in diameter and weighing approximately 2500 lb., that had been badly broken and almost pulverized in parts, was repaired by arc welding at a cost of $80. A new gear would have required the outlay of several hundred dollars.

† General Electric Co., Schenectady, N. Y.

The repair work was done by the Menna Welding Company of Toledo, Ohio, using a single-operator welding generator. One new spoke and a new section of the rim representing about seven teeth of the gear had to be cast and welded into position to replace parts of the gear which had been too badly shattered to be reassembled.



The Broken Gear Wheel before and after Welding

Electric Welding in Japan

By MINORU OKADA†

Abstract

THIS report deals with the description of the recent progress of electric welding in Japan including the outlines of research work. Special features in arc welding in Japan are the use of alternating current welding machines and coated electrodes. The amount of consumption of electrodes in the leading factories for use in electric welding is given, showing the progress of industrial applications of electric welding in the last five years. Some photographs of arc welded buildings, tanks, vessels, etc., are given illustrating these welding applications. Among the research work prominent scientific investigations such as structure of the welding arc; welded structures, mechanical and electro-magnetic properties of deposited metal; welding of special steels, cast iron, non-ferrous metals, and alloys; and finally on economical effects are included.

Section 1. Industrial Applications of Electric Welding

Welding Machines.—A number of manufacturers have developed various types of machines. Noteworthy progress has been made in the development of all types of resistance welding machines, that is, butt welding machines, spot welding machines, seam welding machines, etc.

† Assistant Professor of Metallurgy, Osaka Imperial University.

Fig. 1—Alternating Current Welder, Capacity 400 Amperes

Fig. 2—The Building Structure of Daimaru Department Store Reinforced by Electric Welding

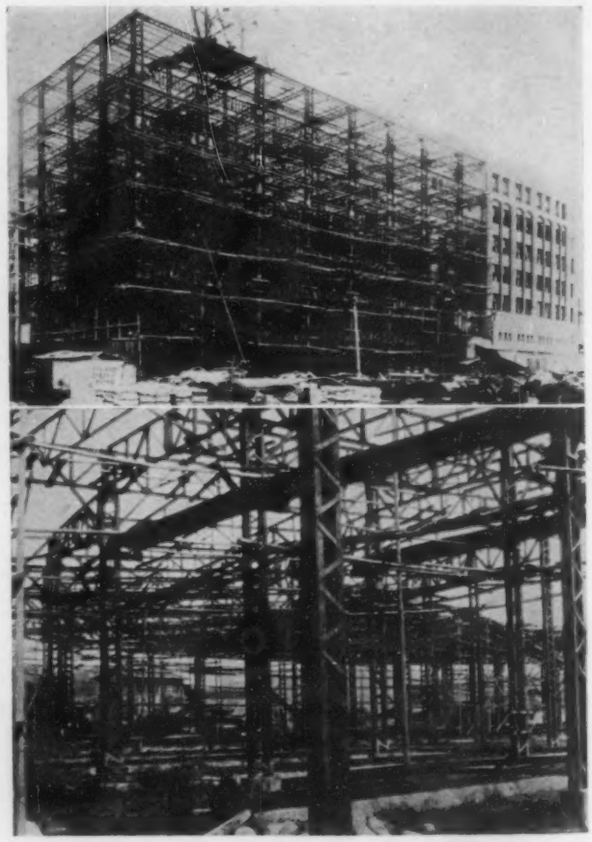


Fig. 3—All Welded Structure of Car Barn of Japanese Government Railway

Arc welding may be done with direct or alternating current. Several types of direct current welding equipment are available. These include constant current, constant voltage and constant energy machines. In the constant current generators modified differential compound, Rosenbery type, and split pole type have been manufactured as single operator units and by adjusting circuit resistance the welding current may be controlled from 20 to 300 amperes.

Properly designed transformers with taps and leakage core arranged to adjust the welding current to suit the work, is usually used as a source for alternating current for welding purposes. Alternating current arc welding machines have many advantages in practice. They are rugged in construction and the price is only one-fifth to one-half as much as that of the direct current machines for the same capacity. The alternating current

welders have secondary open circuit voltage ranging from 60 to 250 volts and welding current may be adjusted from 20 to 300 amperes and in some cases even up to 700 amperes. In general, the higher the secondary open circuit voltage the easier it is to start an arc, but if such machine is used, welder should be very careful and guard from the electric shock especially during the high humidity season of the Japanese summer. Disadvantage of the alternating current welding machine from the power distribution standpoint is its low power factor. According to the author's investigation with coated electrode in which 4-mm. electrode is used the maximum power factor of welding energy ranged from 20 to 40%, in order to secure a stable arc. Alternating current welders with high frequency generator came into use for the welding of thin steel or non-ferrous metal plate. In this welder, high frequency current is superposed on the welding current and by ionizing the air gap between the electrode and the work a stable arc is secured. In this type of welder, welding current may be adjusted from 10 to 100 amperes and if necessary, which is very seldom, even up to 500 amperes. Several types of metal and carbon arc automatic welders are used in pipe and tank manufacturing industry. For welding of stainless steel, monel metal, copper alloy and other metals, the atomic hydrogen welder is utilized.

Welding Rod.—Welding rod includes welding wires, and cast rods of practically every commercially used metal. Low carbon steel wires are used to make the welding rod for structure steels. Recommended chemical compositions of welding rod in common use expressed in per cent are as follows:

C 0.12 Si 0.05 Mn 0.35–0.55 P 0.04 S 0.04

If direct current welder is employed, bare electrode would be applicable, but, as mentioned previously, alternating current welders are in common use in Japan, therefore the majority of welding electrodes being used are coated electrodes. In metallic arc welding it is better to use flux containing deoxidizer and alloying elements to maintain the stable arc and to make the modification of the deposited metal. Some examples of the chemical composition of coating materials are as follows:

Component	Kind of Flux A	B	C	D
Ferro-manganese	20	16	13	..
Magnesia	8	..	..	..
Lime	26	20	..	20
Asbestos	25	..	23	..
Borax	20	24	27	24
Potassium ferrocyanide	..	16	11	5
Manganese dioxide	..	8	16	20
Aluminium powder	..	8	..	..
Sodium silicate	..	7	11	..
Anhydrous sodium carbonate	..	..	..	..
Silica	..	4	8	..
Sodium bisulphate	..	..	..	13

As the useful deoxidizer manganese, aluminium, titanium, silicon and its ferro-alloys are employed. The following metals such as nickel, chromium, tungsten, molybdenum, vanadium, copper and also their alloys are available to modify the deposit metal.

The welding wires made from mild steel, nickel, monel metal, bronze, cast iron and malleable cast iron together with suitable flux are used for welding of cast iron. The cost of nickel and monel metals is high but for special purposes their use is profitable. The use of bronze for welding cast iron is sometimes limited due to the fact that its color differs from that of the cast iron.

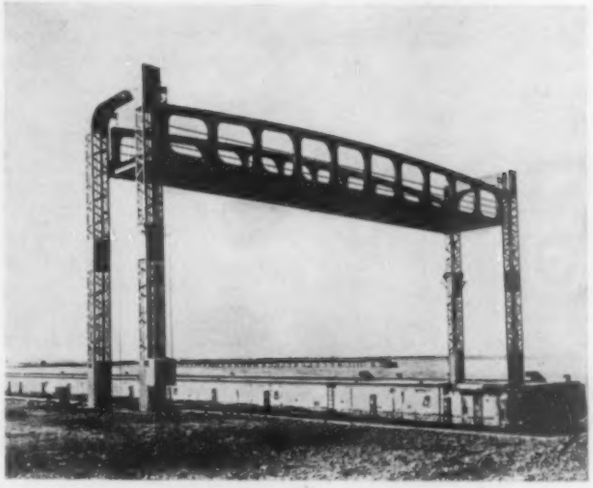


Fig. 4—All Welded Lift Bridge—Span 20 M., Lift 9 M.

There are two classes of welding rod for the use of alloy steels, one containing the necessary alloy element in the core wire and the other in coating material. Nickel as a fine wire form and aluminium, manganese, silicon and ferro-alloy, etc., as a powder form are added in the coating with a suitable binder but sometimes nickel, copper and chromium are added by electroplating. Most of the filler metals for stainless steel are the alloy of 18–8. Worn parts of the high manganese steel are repaired by the manganese-nickel steel welding rod. For the welding of copper alloys and light alloys, oxyacetylene or oxy-hydrogen welding is more generally employed than electric welding, hence in these cases, the filler metals have the similar composition with the parent plate.

As a guide indicating the progress of electric arc welding in Japan the following table showing the amount of welding rod consumption per year by some of the leading factories using electric welding is given.

Consumption of Electrode by the Leading Factories

Year/Factory	Metric Tons/Year A	B	C	D	E	F	G	H	I	J
1929	16.0	20	....	....	5.3	21.0	10.0	32.0	0.6	3.0
1930	34.0	30.0	1.2	....	6.7	24.0	15.9	43.0	1.0	4.0
1931	40.0	30.0	6.2	14.0	8.5	2	18.0	56.0	1.8	6.0
1932	52.0	50.0	9.8	15.0	10.2	21.0	25.4	76.0	6.5	10.0
1933	80.0	80.0	40.0	24.0	13.6	36.3	29.3	90.0	30.0	20.0

NOTE: Metric ton = 1000 kg.
A, *B* and *C*—Shipbuilding companies.
D and *E*—Car manufacturing companies.
F and *G*—Electric machine manufacturing companies.
H—Iron manufacturing companies.
I—Bridge construction company.
J—Railway repair shop.

Structural Welding.—Important consideration of the building construction in Japan is to resist the earthquakes. Arc welding is now only applied in reinforcing the rivet joints, but the strength gained by arc welding is added in the stress calculation. It has been shown by recent successful results that rapid progress has been made in the art of welding structures. Several all arc welded structures have also been erected. Figure 2

shows the building of Daimaru[1] department store reinforced by electric welding and Fig. 3 shows all arc welded structure of car barn of Japanese government railway.

The reinforcement[2] of bridges made necessary from corrosion, and with the increase of locomotive weights is made almost without exception by electric arc welding. The report shows that the number of plate girders reinforced by electric welding in 1933 were 104 spans, and as a result the length of bridge life has been extended to more than twenty years. Figure 4 shows all arc welded lift bridge. Like this bridge there are many other all arc welded bridges.

Replacement of Castings by Welded Rolled Steel Sections.—The substitution of arc welded structural sections in place of steel castings have revolutionalized both the manufacturing methods and construction costs. Frame, yoke and housing of electric machines and various kinds of machine parts made formerly by casting are now almost entirely fabricated by welded steel plates and as a result the weights are greatly decreased. Furthermore, these welded constructions in strength are by no means inferior to the cast steel structure. Now the weight of electric machines has been reduced by more than 30% and any change in the design is more easily accomplished with steel construction.

Welded Tank, Pipe and Pressure Vessels.—The use of welded storage vessels of air, gases and liquid under pressure for various purposes such as for chemical and petroleum industries has greatly increased. One of the oil refinery tanks[3] with working pressure of 65 kg./cm.^{2} and working temperature of 500° C., which has been constructed by arc welding has 100 mm. in wall thickness. Figure 5 shows the oil refinery tank, and Fig. 6 shows the viscose tank in some chemical works. Where tightness is important as in the construction of tank, pipe and pressure vessels, arc welding shows its superiority. Penstocks 2 m. in diameter, 50 mm. in wall thickness with a working pressure of 45 kg./cm.^{2} are now being manufactured by the Kawasaki Dock Yard Co., Ltd. Figure 7 shows all welded oil tank manufactured by the Mitsubishi Heavy Industry Co., Ltd.

Recently, automatic arc welding has been used with great success in manufacturing steel pipes for water lines and gas mains. These automatic welding machines are

Fig. 5—Welded Oil Refinery Tank, Thickness of Plate 50 Mm., Working Pressure 15 Kg./Cm.^{2}, Working Temperature 500° C.

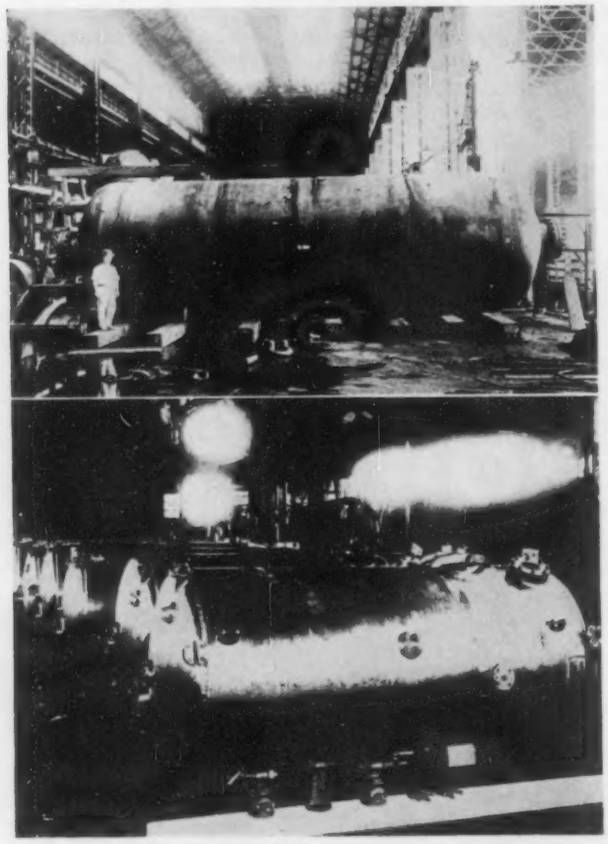


Fig. 6—Welded Viscose Tanks, Thickness of Plate 16 Mm.

Fig. 7—Welded Oil Tanks, Each Capacity 100 Tons

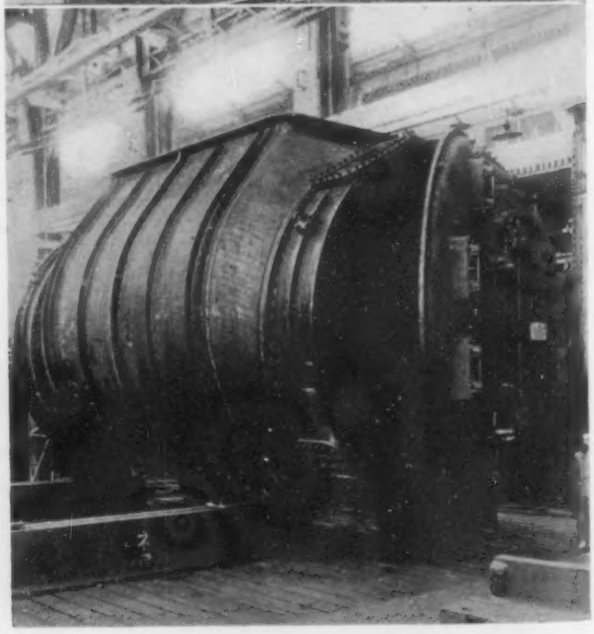


Fig. 8—Welded Casing of Turbine Condenser

used for mass production works in plants such as Mitsubishi Heavy Industry Co., Ltd., and Kawasaki Dock Yards.[4] Figure 8 shows a casing of turbine condenser in which most of the parts are constructed by arc welding.

Welding in Car Manufacture and Railway Track.—Up to a few years ago, in construction of steel cars electric welding was only used in joints of secondary importance, but now it is being applied to important sections of steel cars. New designs for all steel bodies have almost entirely adopted electric welding instead of steel forgings and castings. Today, important parts of steel cars now made by welding process are under-frame, side plate and accessories, etc. The fire-box of locomotive and motor car bodies is also fabricated by welding. Use of welding in railway track is steadily increasing and arc welding, resistance welding, as well as thermit welding, are employed. The heavy coated electrode is generally adopted for joining of electric rail bonds and for repairing special trackworks and for reclaiming worn out rails.

Shipbuilding.—An extensive investigation on the strength of the arc welded joints has been undertaken by our Navy Department. According to the result, the strength of the welded joints is not inferior to the riveted joints, and the material saving and rapidity of work are greater than the riveted construction. For these reasons welding has brought a revolution in shipbuilding industry by practically replacing riveting. Not only various types of naval ships but also merchant ships, fishing vessels and yachts are now mainly fabricated by electric welding. In electric welding the result depends largely upon the skill of welders.

Qualification of Welder and Inspection of Weld.[5]—Before the welder is permitted to weld, his ability to do the kind of work required should be tested. General rule for the qualification of all welders in Japan has not as yet been determined, but in every line of government and industrial welding, codes have been provided to suit their respective work. Qualification test of welders covers the required strength of test specimens and the method of making test specimen. As an example of the qualification requirement, the required tensile strength by various organizations are as follows:

Required	Tensile Strength of Butt-weld Specimen in Kg./Mm.²	
Navy	38	
Army	38	(mean) 35 (minimum)
Railroad	39	(deposited metal only)
B.C.	39	
Boiler Society	39	

As a non-destructive test visual examination of the external appearance of weld, electrical test, magnetic test and X-ray test should be used in practice. Next, the properties of the deposited metal, such as specific gravity, hardness, tensile strength, elongation, etc., should be tested in many cases. These properties are largely determined by the kind of welding rod which is used. For the welded pressure vessels, hydraulic pressure test and hammering under pressure are generally required without exception.

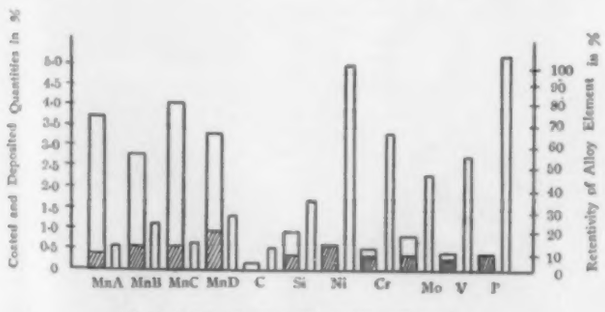


Fig. 9—Change in Quantity of Alloy Elements

Fig. 10 (Top)—Creosote Tank, Capacity 2000 Tons

Fig. 11 (Center)—Gas Main Pipe

Fig. 12 (Lower)—Welded Pontoon, Weight 82 Tons

Japanese Welding Society.—As the center of welding industry, the Japanese Welding Society was established in 1926, but up to 1931, however, it was not recognized in general. Recently, with the progress in this branch of

industry, this organization is highly appreciated by factories and engineers in every line of industry. The trend of increase of its members is shown in the following table:

Year	1930	1931	1932	1933	1934
Number of members	80	260	460	720	810(Oct.)

Section 2. Research Work

Welding Arc.—In usual procedure, the metallic arc voltage in steel welding is greatly affected by the kind of coating materials used and usually ranges from 15 to 25 volts. According to the result of experiment by Mr. H. Shibata, the railroad engineer of the Japanese Government, in which he used direct current welding machine with electrode connected to the negative terminal, welding rod coated with metallic oxide or carbonate lowered the arc voltage as the atomic weight of the element increased; and he also showed that the higher arc voltage gave more melting rate of electrode. By oscillograph the author of present paper showed that the characteristics of the iron welding arc[6] are similar to those of the mercury arc.

Steel Structure.—Dr. T. Naito and Mr. A. Tsuruta,[7] Professor and Assistant Professor of the Waseda University, investigated on the strength of reinforced concrete in which reinforcing bars were welded together. From this result it has been ascertained that the strength of this welder-bar reinforced concrete is 13% greater than the sum of the strengths of the welded joint and reinforced concrete beam, considered separately. They concluded that the rigid welded concrete reinforcing bars are more effective than the ordinary form of loose reinforcing bars. Testing the strength of the structural members joined by the combination of rivet and weld, and by rivet only, they concluded that in this case the combined strength of rivet and weld when used together was about 90% of the sum of their individual strength.

Mr. S. Sasaki,[8] engineer of the Mitsubishi Heavy Industry Co., Ltd., conducted researches on the stress distribution by means of photoelasticity. Mr. S. Asano, engineer of Osaka Prefectural Office, explained the action of load on the front fillet weld assuming that it is similar to the case of cantilever and he derived the calculation formula for stress distribution in front fillet weld. Dr. Y. Tanaka, Professor of Tokyo Imperial University, and Commander T. Fukuda, have published their prominent works on the steel structures and stress distributions.

Deposited Metal.—Good mechanical properties of the deposited metal is the most important factor of structual steel welding. Dr. M. Haramiishi[9] carried out the experiments on the deposited metal of high quality. Recently he succeeded in such a welding that the strength of welded part was more than 80 kg./mm.^{2}. Dr. T. Naito and Mr. A. Tsuruta,[10] as mentioned previously, tested the mechanical properties of deposited metal made from their welding rod and obtained the following results:

Tensile strength—47 kg./mm.^{2} without annealing and 43 kg./mm.^{2} after annealing.
Elongation 10 to 15% in 100 mm. gage length.
Yield point—60% of ultimate tensile strength.
Modulas of elasticity—20,000 kg./mm.^{2}
Impact resistance by standard Izod impact test—2 to 4 kg.-m.

Percentages of the original alloying elements in the coating material which goes into the deposited metal, are much affected by the kind of alloying elements used, component of coating material, especially silicate, degree of slag and welding condition. The author[11] has investigated the effect of different compositions of electrode upon the deposit metal all welded under the same condition. Some of the alloy elements in the coating material when deposited increased in percentage and the others decreased. Figure 9 shows the results of experiments, in which the heavy line represents the quantity of alloy elements originally in the coating and the shaded parts show their quantities in the deposit metal; while light lines represent their retentivities. Retentivity of manganese is much affected by the coating materials and welding conditions and these effects are shown in the following table:

	Covering or Coating Materials	Welding Conditions
Mn A	Blue asbestos	Wide weaving
Mn B	Coating materials	Wide weaving
Mn C	Blue asbestos	Straight beading
Mn D	Coating materials	Straight beading

About the electromagnetic properties of the deposited metal in arc welding, the author[12] has published his experimental result. The purpose of this investigation was to obtain the proper deposited metal applicable to the welding of electric circuit or magnetic circuit. The various kinds of deposited metals were tested to find the electromagnetic properties, mechanical properties and change of these properties before and after aging or annealing, and the results are as follows: The electric resistivity of deposited metal from low carbon bare electrode was comparatively small. For welding of magnetic circuit, electrode coated with proper quantity of silicon and manganese is applicable. However, manganese itself does not afford good effect to magnetic properties of deposited metal, but it serves to reduce the degree of atmospheric contamination. One of the most important facts discovered by this research is that the deposited metals in general possessed the remarkable aging property and this is largely influenced by its nitrogen content. But by the addition of silicon and manganese the increase of hysteresis loss by aging was almost negligible. The magnetic characteristics of deposited metal were much altered by its cooling rate after annealing, especially below 500 degrees centigrade. The deposited metal from the covered electrode in which silicon and manganese were added possessed superior quality in mechanical properties.

Welding of Cast Iron.—Research on the metallic arc welding of cast iron is one of the most interesting problems for welding engineers. Mr. S. Sasaki[13] made use of cast-iron rod with coating material promoting the graphitization. If the welding rod containing suitable quantities of carbon, silicon and phosphorus is used and if the work is allowed to cool slowly after welding, the deposited metal becomes gray cast iron and no crack and no hard part are produced. This non-cracking property is due to the fact that the thermal shrinkage is cancelled by the expansion of metal owing to the separation of graphite. As the graphitization agent, he recommended the use of carborundum and phosphorus. He explained these beneficial effects due to the property of phosphorus which served to lower the solidifying temperature and help to set free the included gases and thereby secure the sound deposit. Mr. U. Hashimoto,[14] Professor of the Tokyo Technical College, also experimented with the cast-iron electrode in which less than 1% of aluminium is added. He reported that a favorable success was obtained in his experiment. The author found that the electric resistivity of welding rod such as cast iron has much influence on the melting rate of the electrode

and that the changes in melting rate caused irregularity of cooling rate and of the structure of welded part. He then applied malleable cast-iron rod whose resistivity is about one-half that of cast iron, with coating material containing proper amount of ferro-silicon, phosphorus, carborundum, etc., and succeeded in obtaining a soft and machinable welded part. Using this electrode, sufficient penetration and higher tensile strength in welded parts could be secured. However, in case of semi-steel, the work should be sometimes heated to maintain slow cooling rate, even if the above electrode is used, because the separation of graphite in this metal is very difficult in the ordinary welding condition.

Welding of Non-Ferrous Metal.—It is most important that the proper flux be applied for the arc welding of aluminium. Dr. T. Okamoto, Dr. H. Nishimura and Mr. I. Onishi,[16] Professors and Assistant of Kyoto Imperial University, conducted research work on this problem. These fluxes should not lose their welding properties, even when exposed in air for a long time. According to their experimental result flux containing Na_3AlF_6 50% and KCl 50% or Na_3AlF_6 24%, KCl 38% and NaCl 38% was favorable for arc welding of aluminium. They reported that one of the fundamentals to keep in mind in arc welding procedure of aluminium is to apply heavy current at start. The arc welded specimen showed greater tensile strength and less adjacent part of weld of reduced hardness than those welded by oxyacetylene.

They investigated on the arc welding of "silmin." In this case the content of silicon in the deposited metal was reduced from 20 to 40% of that of the original content. Also the addition of silicon in flux caused irregularity of deposited metal and gave no favorable influence to the modified structure.

Mr. S. Sasaki has published a part of his research in regard to bronze welding. The low solidification temperature and the long interval of solidification in such metals served to reduce blow-holes. But the difficult point of bronze welding is that it has a great coefficient of thermal expansion and he said that the rapid cooling is the principal difficulty and the proper cooling apparatus should be used for bronze welding. Among the alloy elements of bronze, about 10% of zinc is oxidized in the arc but the other elements are almost retained in the deposited metal. For a flux used in bronze welding, he recommended a mixture of deoxidizing agents such as halogen compounds of alkaline earth.

Resistance Welding.—Dr. T. Okamoto[18] has published a prominent research work entitled "Theoretical and Experimental Researches on Electric Resistance Welding." The heat quantity developed on the butt surface is not so large as has been commonly supposed and the production of heat necessary to raise the plates to the welding temperature is rather produced by that part of the current flowing through the bar, especially in the neighborhood of butt surface, where the electric resistivity increases rapidly with the temperature rise. These phenomena were illustrated by oscillograph in his report.

Research Work in the Economy of Arc Welding.—Comparing to riveting, two principal merits of electric welding are the reduced cost and the better product. Mr. H. Okayama has studied the economical factors in the use of arc welding on some practical examples which have been constructed recently. The result of this investigation showing the saving of material, labor and total cost, when welding is substituted for riveting, is given in percentages for four applications in the following table:

Creosote tank (capacity 2000 ton) (see Fig. 10).

Item	Per cent of saving
Material	12
Labor	23
Total	22

Gas pipe (diameter 1 to 2 meters, length 4200 meters) (see Fig. 11).

Material	22
Labor	45
Total	27

Water pipe (length 12,000 meters, weight 3600 tons).

Material	8.5
Labor	34.6
Total	28.5

Hot stove

Material	24
Labor	20
Total	22

According to Mr. T. Ujiie,[19] the engineer of Mitsubishi Heavy Industry Co., Ltd., the saving in material in such a pontoon shown in Fig. 12 is distributed as follows:

	Saved Weight	
	Per cent of total	Amount in ton (1000 kg.)
Overlapping of plate at joints	4.0	3.45
Angle iron knitting structural part	9.0	7.25
Liners	1.0	0.8
Rivet heads	2.0	1.6
Total	16.0	13.10

Research.—Research problems for electric welding proposed by the committee on electric welding in the Nippon Gakujitsu Shinkokai (Institute for Advancement of Science and Art in Japan) in 1933 are as follows:

Electric welding of thin plate
Electric welding of thick plate
Electric welding of special steel
Electric welding of cast iron
Electric welding of copper and its alloys
Electric welding of light metals
Fundamental research on welding electrode and coating material
Improvement of the reliability of welded part
Working stress in welded part
Simple and effective inspection method on weld
Detail consideration of welded joint
Stress transmission on welded joint
Test specimens and testing methods

Conclusion

During the last five years electric welding in Japan has made remarkable progress in both industrial applications and scientific researches as explained, and the author expects its brilliant future in the various industrial lines; and Japan could surely cooperate with the world progress of this branch of metal working.

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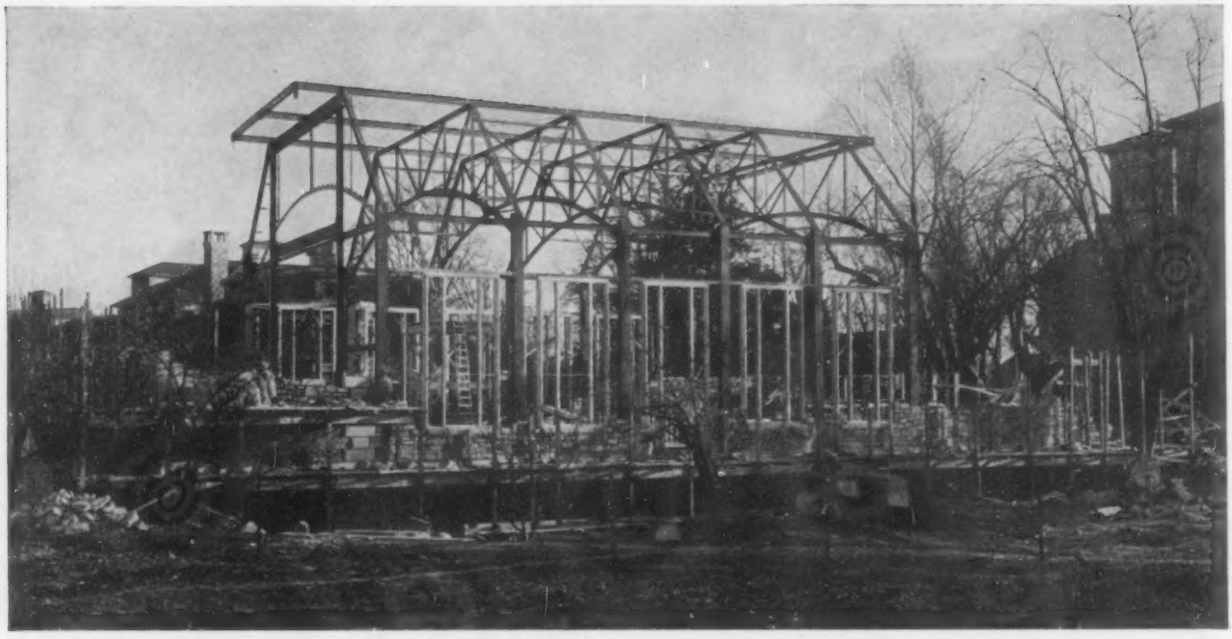

Fig. 2—View of Welded Trusses and Welded Roof Beam Construction

Spring Grove State Hospital Auditorium Building

By VAN RENSSELAER P. SAXE†

THIS building is constructed in a group used for hospital purposes and adjoining a large administration building used to house doctors and hospital staff.

Because of the type of building it was necessary to construct it with a steel frame with steel columns to support exterior walls, this being made necessary because of the large windows opening between piers.

Because of its location, it was decided that if costs were not too much more, that it would be desirable to build it as a welded steel frame rather than a riveted frame and preliminary studies were made in the design of each type of structural frame to determine any possible differences in cost.

† Consulting Civil Engineer.

Fig. 1—View Showing Welded Plate Girder and Welded Trusses

These studies indicated that while a welded structure might cost more so far as actual welding cost over riveting was concerned, still enough saving in weight of material in the design of plate girders and trusses and connections could be made in the welded design to offset this assumed difference in the welding cost.

On the basis of this preliminary information we determined to design the steel frame as a welded job rather than riveted and the completed design indicated that we saved by using a welded design about 12% of the total tonnage of steel required by the riveted design and we found that the cost of the shop and field welding work was slightly less than the cost of riveted connections, so that the net saving on the steel frame by using the welded design was about 13% less than the costs using a riveted design.

In general the welding and welding design followed the specifications of the AMERICAN WELDING SOCIETY. All welding operators were qualified by the National Weld Testing Bureau and all steel was subject to mill, shop and field inspection by inspectors of the Pittsburgh Testing Laboratory and all shop and field welding work was inspected by the National Weld Testing Bureau using the stethoscope as the chief means of making direct inspection of the welds.

All welding rod used was the heavy coated shielded arc type.

In connection with these tests and inspections it is interesting to note that the welders developed such a high quality of work that there was no condemnation of any of the welding done on the job, and it might be advisable to state here that this was probably due to the severity of the original qualification tests, which the men were re-

quired to pass, and to the fact that each man was given a steel stencil cutting number with which he was required to stamp each weld that he did, so that on inspection of the work, the welding of each operator was clearly marked and they could have no way of placing blame on some other operator in case of difficulty with any single stretch of weld application.

Further, when working on the field welding each operator was required to have his welding qualification paper with his photo attached to the original paper so that the contractor's job superintendent could identify the men working on the job.

Except for the original qualification tests the expense of testing of field and shop welding was no greater than would be the case in a riveted job.

In consideration of the design of a welded steel frame it is often advisable to try to forget the common practice as required for a riveted structure. The general details of riveted construction if applied to a welded structure do not give one the full advantages that can be secured by the use of welding. It is advisable to develop methods best adapted to welding and while this requires some originality, one soon gets used to the new methods that are required.

In a welded job because of the lack of any standard welded connections such as one has in the handbooks on steel construction the engineer designing the job is obliged to place more illustrations of details of connections on plans for information of the shop people making shop detail drawings than are usually shown on the engineers' plans for a riveted job. In this particular building we followed this practice and the job was shop detailed by a firm of engineers who had no previous experience in this type of work and who were able to detail the job from the information contained on the engineering plans with practically no request to our office for additional information. Our inspection and approval of these shop detail drawings required no more changes than we would usually have to make in a set of riveted steel shop drawings for the same type of building, for we find just as many errors in getting the right number of rivets in a connection point as we do in getting the proper number of inches and size of weld.

Fig. 3—View Plate Girder Connection to Column

Fig. 4—View Showing Truss Connection to Columns

It might be of interest that these detailers took this job for the same ton price they would have gotten for a riveted job and they advise us that they came out just as well as on a riveted job and state that after the short time required by their men to get used to the welding details that they made just as good progress as on any jobs they have ever done and while they had always thought there was some mystery about welding, they were surprised to find how simple it really is when applied to shop drawings.

Some of the interesting points in the design of the steel for this building to suit a welded design were determined by the conditions that would probably occur during its construction. Because of the type of building in which steel columns in the walls run from the foundations to the underside of the roof trusses, the contractor would probably erect the columns and first floor beams to support the columns in place, then place the first floor concrete to give a working surface for the assembly of the trusses which would be shipped to the job in half lengths, welded on the concrete floor and lifted in place as a complete unit.

The steel in the building was held in place by the welded steel erection seat shown in the illustration. This seat is furnished by the Schuster Engineering Company. The details shown herewith show the application and use of these seats which hold the unwelded parts of the structure more firmly in place than can be done by the use of erection bolts. All of the beams, plate girders and trusses were held in position by this method and actual field welding was not started until all of the steel in the floor and roof was in place on the erection seat, then plumbed and lined up and made ready for the field welding in its final position.

In the design of the first floor steel we used the System M beams, and System S beam which is a welded structural frame made of angles and plates for these types of beams gave us a steel tonnage comparable in cost to a reinforced concrete beam system and at the same time it

gave us a structural beam system across the building, to serve the purpose of keeping the columns properly tied together and plumb until the first floor could be concreted and the roof trusses placed between the columns after the first floor was completed. That this was successfully accomplished is evidenced by the fact that the trusses which had to be placed to a neat fit between the columns were put in place with no difficulty and with exact clearance for the direct welding required between the trusses and the columns.

Probably the most interesting feature of the job is the plate girder and truss designs. The plate girders were designed with a web plate and two cover plates welded to web with intermittent welds. The stiffeners were single plates welded to web and flange plates with intermittent welds. Designing this plate girder as a welder girder saved about 20% of the steel that would have been required for a similar plate girder designed for rivets. The steel fabricating shop who had never before built a welded girder had no difficulty in its assembly and welding and advise that it was much more economical to construct than a similar riveted girder.

The design of the roof trusses was complicated by the fact that the bottom chord had to be curved to suit the contour of the ceiling of the auditorium, rafters for which had to be supported directly on the bottom chord of the truss. After working several designs we found that using a split I beam section for the top and bottom chords produced the most economical truss as it permitted us to have the split I bent to the contour required for the ceiling and gave us welding room at all panel points for our vertical and diagonal truss members. The trusses were fabricated in one-half sections in the shop and shipped to the job in this shape. They were then laid out on the first floor and after being welded together at the center point, they were raised in place to their position on the erection seats, where they were left until the roof rafters, steel, etc., had been placed between them after which they were welded in place to the columns.

Henry P. Hopkins was architect for this building and he, with the owners, was well satisfied with the results secured by using a welded steel frame, as it accomplished all that was expected of it in addition to actually saving money on the cost of the building.

The steel work was fabricated and erected by the Acme Steel and Engineering Company of Baltimore.

Magnetic Characteristics of Metal Deposited by the Oxyacetylene Welding Process*

By WENDELL FREDERICK HESS† AND ROBERT LEE RINGER, JR.††

Introduction

THIS investigation was a continuation of work started in 1931 under the direction of Dr. W. F. Hess at Rensselaer Polytechnic Institute, and was proposed by the Fundamental Research Committee of the AMERICAN WELDING SOCIETY. The experimental work was carried on by Mr. Ringer as a student at the Institute.

The previous investigation was limited to metals deposited by arc welding and by atomic hydrogen welding. The results of this work were presented to the AMERICAN WELDING SOCIETY at its thirteenth fall meeting in a paper by Dr. Hess and were published in the JOURNAL of the Society, Vol. 12, No. 10, pages 21–24 (October 1933). At that time, it was suggested that further investigation be made into material deposited by the oxyacetylene process.

As in the previous investigation, the magnetic properties were determined for samples of completely deposited metal. Even though the method adopted in building the samples is different from actual welding conditions, some idea of the magnetic properties could be obtained.

Several commercial rods and some special iron-silicon alloys, designed for superior magnetic characteristics, were investigated. The metal was deposited wholly by oxyacetylene welding.

The ring ballistic method was used for magnetic testing. This is considered the simplest and most accurate method.

Preparation of the Samples

Standard commercial oxyacetylene welding gases and equipment were used in preparing the samples. The rod to be tested was used in building up a circular mass of metal, about three inches in diameter and one inch thick. Care was taken to remove scale formed, by careful manipulation of torch and rod, and where necessary, brazing flux was employed to carry off the scale. The usual thickness of a layer of metal was about one-eighth of an inch. Layer after layer was laid until sufficient thickness of metal was deposited to give the samples described above.

The welding was performed by the manufacturers of the equipment and gases used, which insured the best available technique. The rough samples were carefully machined to the proper dimensions, care being taken that the test specimens should not include any of the metal within a quarter of an inch of the surface of the rough mass.

The iron-silicon alloys were prepared in a high frequency induction furnace, using Armco iron and ferrosilicon. The silicon was added just before the ingots were cast. The ingots were subsequently rolled into $^1/_4$-inch rods.

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* Contributed to Fundamental Research Committee.

† Assistant Professor of Electrical Engineering and Physics, Rensselaer Polytechnic Institute.

†† Now with Wilson Welder and Metals Co., Inc.

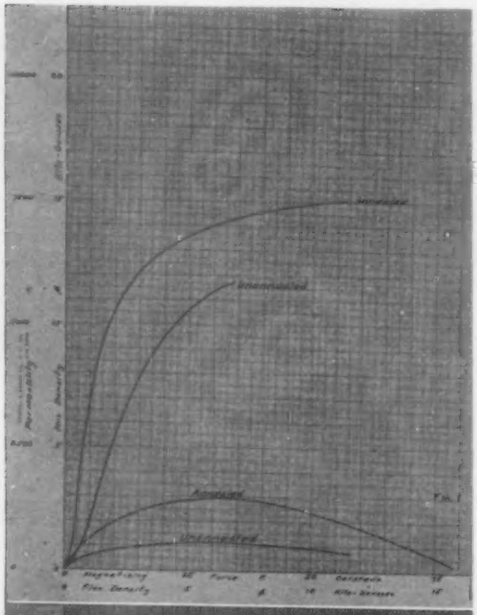


Fig. 1—Magnetization and Permeability Curves for Commercial Vanadium Rod, Both Before and After Annealing

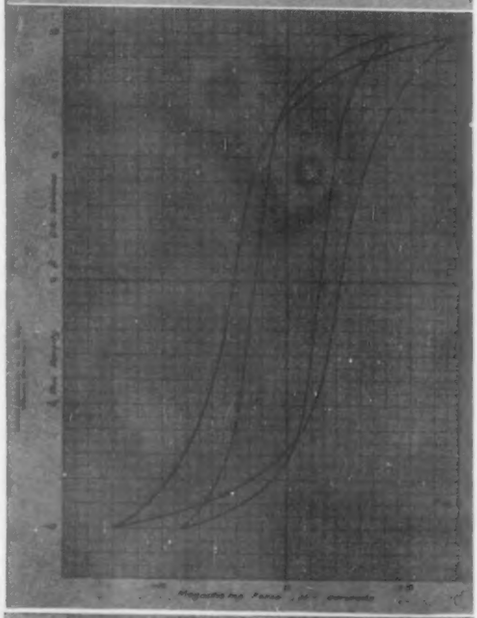


Fig. 2—Hysteresis Loops for Commercial Vanadium Rod, Both Before and After Annealing

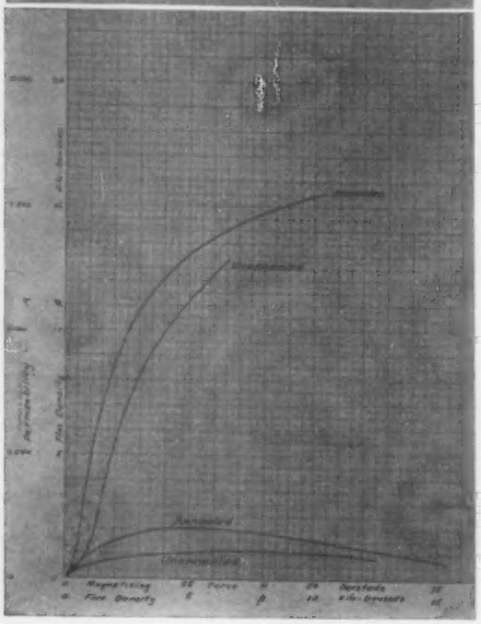


Fig. 3—Magnetization and Permeability Curves for Commercial Nickel Vanadium Rod Both Before and After Annealing

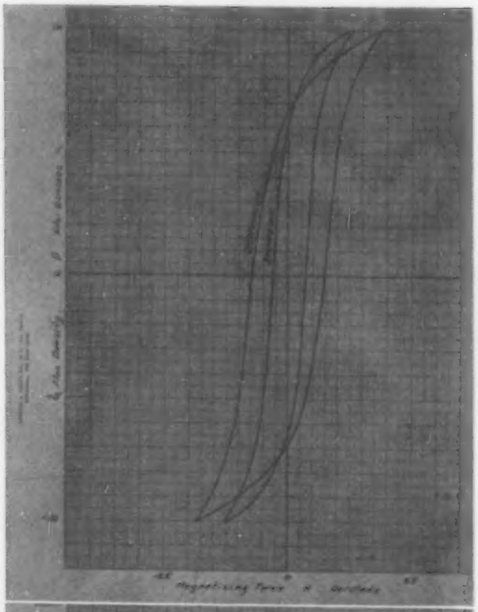


Fig. 4—Hysteresis Loops for Commercial Nickel Vanadium Rod, Both Before and After Annealing. Note Changed Scale of Magnetizing Force

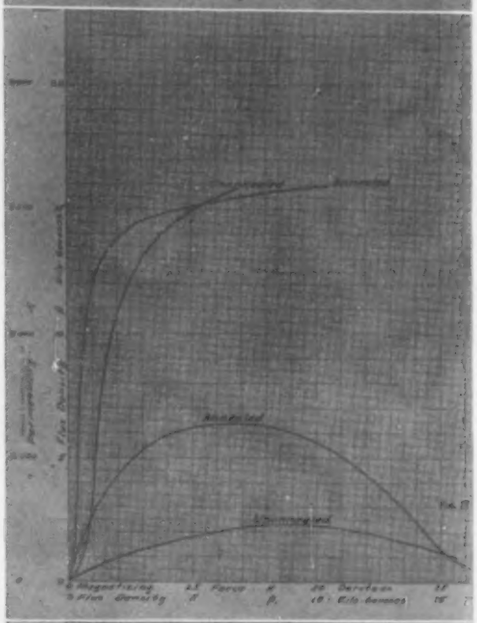


Fig. 5—Magnetization and Permeability Curves for Commercial Low Carbon Rod, Both Before and After Annealing

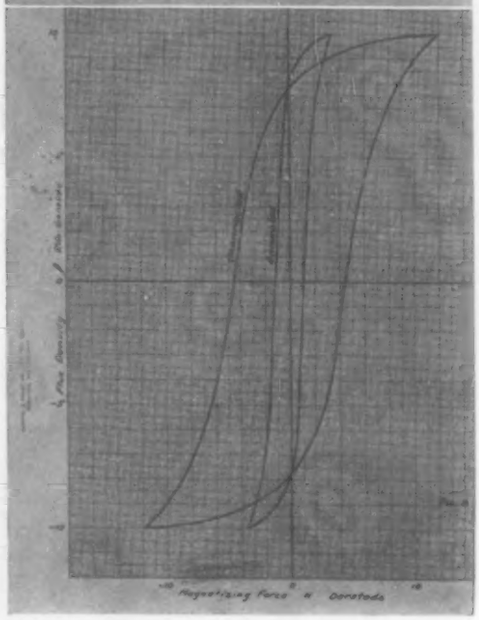


Fig. 6—Hysteresis Loops for Commercial Low Carbon Rod, Both Before and After Annealing

Composition of Alloys

As Cast		After Welding	
% Iron	% Silicon	% Iron	% Silicon
95.5	4.5	95.65	4.35
97.5	2.5	98.10	1.90
98.5	1.5	99.54	0.46

All samples were annealed to find the effects of heat treatment on their magnetic properties. They were tested both before and after annealing. The annealing was carried on for two hours at 1000° C. in an atmosphere of hydrogen so as to prevent oxidation.

Composition of Commercial Rods

	Vanadium	Nickel Vanadium	Low Carbon
Carbon	0.12	0.11	0.05–0.12
Manganese	0.94	0.58	0.15–0.25
Phosphorus	0.010	..	0.03 max.
Sulphur	0.011	..	0.03 max.
Silicon	0.16	0.22	0.05 max.
Vanadium	0.19	0.22	.....
Nickel	0.10 max.	2.27	.....
Chromium	0.10 max.	0.15	.....

Table of Results

Rod Material	State	u max.	At B Gausses	Hysteresis Loss Watt-Secs./-Lb./Cycle
Vanadium	U	560	6000	0.0707
Vanadium	A 1000	1440	6700	0.0444
Nickel Vanadium	U	565	7200	0.1071
Nickel Vanadium	A 1000	1060	5200	0.0509
Low Carbon	U	1115	8600	0.0794
Low Carbon	A 1000	3180	7000	0.0200
0.46% Si	U	2060	7000	0.0272
0.46% Si	A 1000	3520	7100	0.0180
1.90% Si	U	2100	5600	0.0234
1.90% Si	A 1000	8225	7800	0.0097
4.35% Si	U	1940	4000	0.0175
4.35% Si	A 1000	3650	4200	0.0088

List of Symbols in Results

u max.	Maximum permeability
B	Flux density in gausses
U	Unannealed
A 1000	Annealed, 2 hours at 1000° Centigrade
watt-secs./lb./cycle	Hysteresis loss in watt-seconds per pound per cycle

Discussion of Results

Wherever a comparison is made in this paper between results obtained by the oxyacetylene welding process and those obtained by the electric arc or the atomic hydrogen processes, the basis of the comparison is the combined results of this and the previous investigation.

The results show that ordinary commercial welding rods, with the exception of low carbon rods, produce decidedly inferior magnetic properties. This is probably due to the manganese content of the alloy rods. This low carbon rod, in the unannealed state, is about twice as good as the vanadium and nickel vanadium rods, as far as maximum permeability is concerned. However, from the view-point of hysteresis loss, there is not so much difference.

After annealing, the hysteresis loss of the low carbon commercial rod is very much less than that of the other rods. Annealing makes the maximum permeability from two to three times that in the unannealed state. Annealing reduces the hysteresis loss of the alloy rods to about one-half its unannealed value and that of the low carbon to about one-fourth.

If a special iron-silicon alloy is used, a maximum permeability in the unannealed state of about 2000 is obtained, or about double that of the low carbon rod. The hysteresis loss in the unannealed condition for

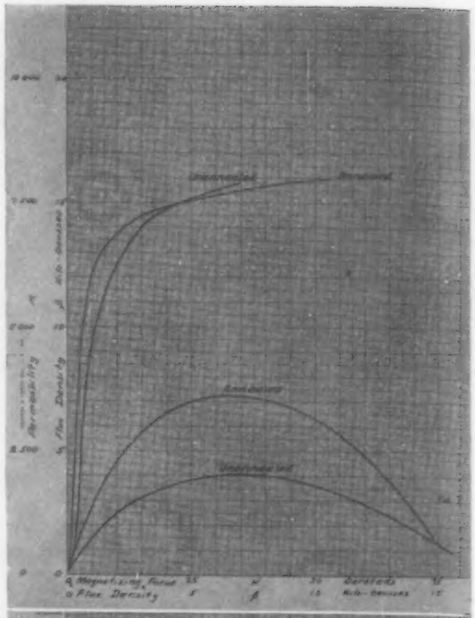


Fig. 7—Magnetization and Permeability Curves for 0.46% Silicon Alloy Rod, Both Before and After Annealing

Fig. 8—Hysteresis Loops for 0.46% Silicon Alloy Rod, Both Before and After Annealing. Note Changed Scale of Magnetizing Force

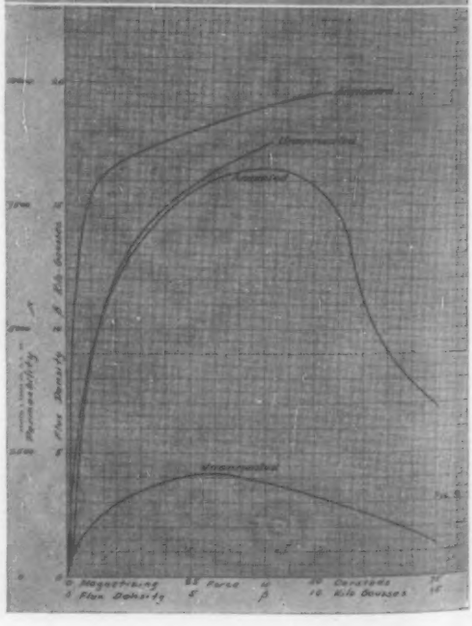


Fig. 9—Magnetization and Permeability Curves for 1.90% Silicon Alloy Rod, Both Before and After Annealing

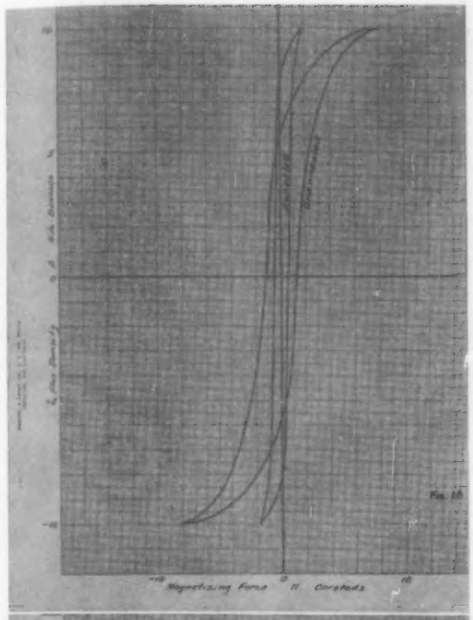


Fig. 10—Hysteresis Loops for 1.90% Silicon Alloy Rod, Both Before and After Annealing

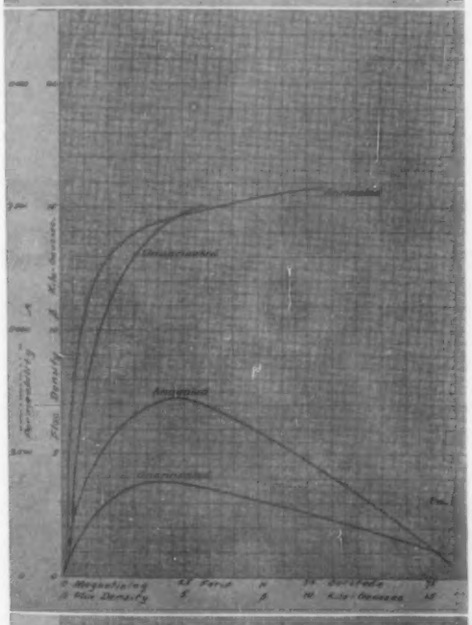


Fig. 11—Magnetization and Permeability Curves for 4.35% Silicon Alloy Rod, Both Before and After Annealing

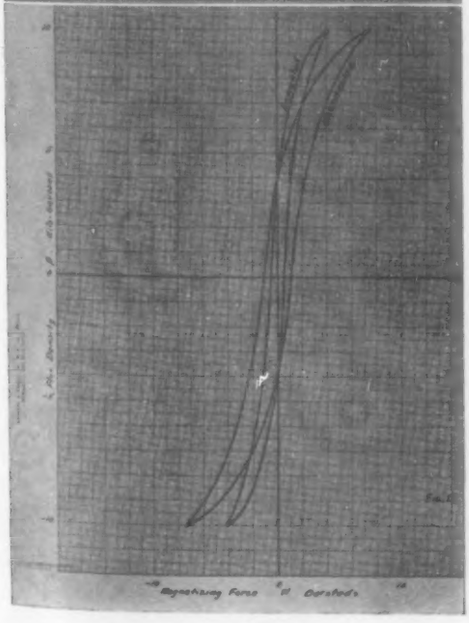


Fig. 12—Hysteresis Loops for 4.35% Silicon Alloy Rod, Both Before and After Annealing

these alloys is about 0.02 watt-seconds per pound per cycle, or about one-fourth that of the low carbon rod.

In the case of the best silicon alloy, containing about 2% silicon, annealing gave about four times the maximum permeability obtained in the unannealed state. The hysteresis loss in this case is less than half that in the unannealed state, and also less than half that obtained with the annealed low carbon commercial rod.

Conclusions

1. The magnetic qualities of welds made with low carbon rods are markedly better than those made with the other types of commercial oxyacetylene rods tested.
2. Comparing welds made with commercial low carbon rods by electric arc and by oxyacetylene welding processes, the oxyacetylene method gives superior magnetic qualities, especially when the samples are subsequently annealed.
3. Comparing special iron-silicon alloys designed for good magnetic qualities, deposited by both oxyacetylene and atomic hydrogen methods, oxyacetylene welding gives results equal to those of atomic hydrogen welding.
4. Considering the special iron-silicon alloy rods, above a certain minimum, the lower percentages of silicon improve the permeability on annealing to a greater proportion than do the higher percentages. At the same time, the higher percentages reduce the hysteresis loss relatively more on annealing than do the lower percentages. In this matter, this investigation bears out the results of the previous investigation.
5. For optimum magnetic properties, a silicon content of about 2% is indicated.

Flame-Shaping Flywheels

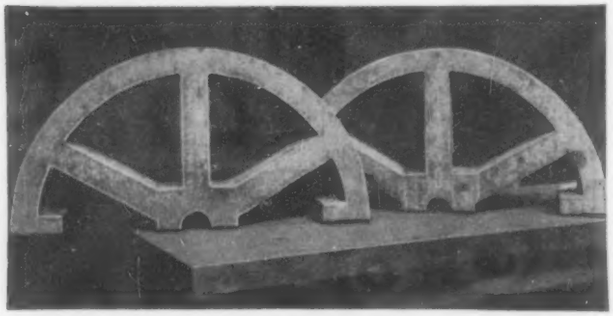
By W. D. WILKINSON, JR.†

Portable Cutting Machine Carves Flywheels from Steel Slabs

INCREASED attention is being focused on mechanically guided oxyacetylene cutting. This is largely the result of the recent introduction of new and greatly improved oxyacetylene equipment for shaping steel parts. In the past, many manufacturers have found oxyacetylene machine cutting an important improvement in their metal working methods. Today the economy and efficiency of the newer machines are found to produce an even greater improvement in the already wide range of this process.

Oxyacetylene flame-shaping has given industry a process that assures more uniform workmanship and greater accuracy in production. The development of this portable machine has made steel shaping even more flexible

† Technical Publicity Department, Union Carbide Company.



The Portable Cutting Machine Job Leaves a Practically Finished Wheel

and practical. While this machine was designed particularly for certain types of work, it is being found admirably suited for much other work of an even wider range. Reports are received every day which indicate that someone has used one of these machines on a new and different job with success.

Shaping of flywheels from heavy slabs of steel, for instance, might seem to be quite a job for a portable cutting machine. But it can be done with ease. Just recently a steel mill turned out a 68-in. diam. flywheel with nothing more than a Monitor cutting machine, the requisite gases to supply the blowpipe and electric current to operate the machine's motor.

A slab of 0.14 per cent carbon and 0.80 per cent manganese steel, 6 tons in weight, 72 in. wide and $9^1/_2$ in. thick, drawn from the mill run, was used.

The flywheel was needed to replace a broken cast iron one on an air compressor in the plant.

Inasmuch as the flywheel was designed to be made in two halves, the first operation was to cut the slab lengthwise in two. Then an oxygen lance was used to cut starting holes through various locations of each slab where sections were to be removed to leave the rim and spokes.

The two parts of the slab were then pushed closely together so that the entire circular cut on both halves could be made with practically the same set-up of the cutting machine. A slight relocation of the machine was necessary between cuts, as the two centers for the semi-circular cuts were different in order to allow the slight over-cut necessary for the finish machining. The two slabs were blocked together on a large cast-iron table and carefully leveled.

A radius arm attachment was placed on the cutting machine and the circular tracks fixed in position. Then the outside diameter of the first section was shaped. Following this the outside cut on the other section was made in a similar fashion.

The next operation was to cut out the sections between the spokes. In each case the cut was started from one of the lance holes in the area to be removed, and moved over to the line of cut. This was done so that when the blowpipe reached the actual line of cut, it would be moving at the predetermined rate.

When the straight line cuts were completed, the smaller circular sections forming the inside of the rim and the hub hole were cut using the circle cutting attachment.

The spokes and rim were cut 5 in. wide. Altogether there was 29 linear ft. of cutting on each half wheel, or a total of 58 linear ft. for the complete wheel.

Linear cutting speed varied between 4 to 5 in. per min. In making the sharp turns where the spokes joined the rim and hub, the speed was slowed down to below 4 in. per min. in order to reduce the lag in the cut.

In cutting the $5^1/_2$ in. diam. hub hole an interesting set-up was made. The circle cutting arm or attachment projected in from the same side of the machine as that on which the blowpipe was mounted. When the machine moved, it followed a path of greater diameter than that of the blowpipe. For cutting larger circles, the circle cutting attachment extends out on the side opposite the blowpipe, and the machine operates on a smaller diameter path than that of the blowpipe. For this work on the small diameter cut, the set-up resulted in a machine running speed of 24 in. per min. while the blowpipe actually traveled only about an in. per min.

Following the shaping of the flywheel sections by means of the Monitor, the spokes were rounded off with a hand-operated blowpipe to give them a somewhat oval cross section. The wheel was then finish-machined.

The Monitor Makes a Smooth and True Rim Cut in Shaping One Section of a Flywheel

This is but one of the many various jobs in which this portable cutting machine has been adapted to rather specialized work. One of the advantages of the portable machine is that it can be carried to the work. This, as in the case of these heavy steel flywheel sections, means a considerable saving in effort and time.

The full range of usefulness of the oxyacetylene shape-cutting process will only be developed by new application. Likewise the complete range of utility of the portable cutting machine will develop as new demands are made on it. As more manufacturers become familiar with the economies and adaptability of this type of machine, such demands will be made and new uses will result.

The Design of Welded Seat Angle Connections—Flexible Type*

By HEATH LAWSON†

THE data in the report "An Investigation of Welded Seat Angles" by Inge Lyse and Norman G. Schreiner of Lehigh University published in the American Welding Society JOURNAL, February 1935, confirm a theory for the design of flexible seat angles developed by the writer for use in the Engineering and Drafting Departments of the McClintic-Marshall Corporation.

It is not generally recognized that the stresses in the outstanding leg of a flexible seat angle and in the web of the supported beam are interdependent. If the seat is too stiff there is a partial restraint of the end of the beam and a concentration of stress in the beam web over the toe of the seat angle. If too flexible the concentration occurs at the end of the beam.

For a well balanced design the beam seat must be capable of permitting as near free end deflection as possible without failure in the seat, and yet of distributing the load along the beam web to prevent buckling.

The top angle should also offer as little restraint as possible to the beam deflection, but should be designed to support the beam laterally to reduce buckling stresses. The top angle shown in Chart A is the most flexible standard angle available, being approximately six times as flexible as the common riveted top angle. The value of the welds is slightly better than the rivets in the riveted top angle.

In Chart A opposite the curve for thickness of seat angle is a diagram representing the relative position of the seat and beam before the load is applied. In this theory of design, it is assumed that under full design load, the beam deflects through a certain angle at the support, and that the outstanding leg of the seat angle also deflects through this same angle. This means that the beam and angle are in contact for the full bearing length. It is then further assumed that the beam reaction, distributed over the length of bearing, measured from the end of the beam, which will produce the maximum allowable buckling stress in the beam web, will simultaneously produce the maximum allowable bending stress at the edge of the fillet in the horizontal leg of the seat angle.

In the upper left-hand corner of Chart A is shown the method of obtaining the moment arm e from the values given in the steel handbooks. Applying this value, the moment $M = R\,[e - (T + {}^3/_8)]$. R is in kips, all other values in inches. Since the allowable bending stress is 18 kips per square inch and the section modulus of the section at the edge of the fillet is $\frac{WT^2}{6}$

$$\frac{R\,[e - (T - {}^3/_8)]}{18} = \frac{WT^2}{6} \text{ solving, } R = \frac{3WT^2}{e - t - {}^3/_8}$$

The lower diagram shows the assumptions upon which the weld design is based. If the seat is proportioned as described above, with a weld length equal to the length of the vertical leg of the seat angle and with a weld size not less than 75% of the angle thickness, the neutral axis will be approximately $\frac{2}{3}A$ from the top of the weld. The location of the neutral axis has not been determined analytically but is the result of judgment based on a study of the behavior of stiffened and unstiffened seats both riveted and welded. The accuracy of this assumption is confirmed by the test results obtained by Inge Lyse and Norman G. Schreiner.

The reasoning back of this lowering of the neutral axis below the center of gravity of the welds, is that the flexible leg of the seat angle deflects toward the column until it bears against the column and takes the compression below the neutral axis, while the tension above the neutral axis is taken by the welds. This tension force is obtained by dividing the moment Re by the lever arm of these forces $(\frac{2}{3}A)$ giving $\frac{3Re}{2A}$. This force is represented by the shaded area in the diagram. Dividing by $\frac{2}{3}A$ and $^1/_2$ we obtain the unit force at the top of the weld. This horizontal force equals $\frac{9Re}{2A^2}$. The vertical unit shear equals $\frac{R}{A}$. If we consider these two forces acting on a unit of area, the resultant shear is $\sqrt{\left(\frac{R}{A}\right)^2 + \left(\frac{9Re}{2A^2}\right)^2}$. Equating this value to the allowable shear of $8D$ kips per linear inch of weld, and

* Contribution to Fundamental Research Committee.
† Engineer, McClintic-Marshall Corporation.

solving for R we obtain $R = \dfrac{16AD}{\sqrt{1+\left(\dfrac{4.5e}{A}\right)^2}}$. In this derivation the pair of welds are considered as a unit.

Table 2 is a reproduction of Table 2 of the Report, to which have been added three columns to show comparison between tests and designs based on Chart A. Using the angle sizes and welds of the specimens we obtain from the chart the allowable loads based on welds (column 10) and on angle thickness (column 11). Column 12 represents the writer's opinion of the specimens based on a comparison of columns 10 and 11. It is considered that in a well balanced design these values would be identical. The length of the seat angle has been added to column 2. This length corresponds to W on the chart.

No detailed comparison will be made with the "B" series tests of the Report. The beam used, a 20 I 81.4, had a 0.6 in. web thickness and the seats were 4 x 4 x $^1/_2$ and 6 x 4 x $^1/_2$ angles. The extreme flexibility of the seats, carrying such a thick web resulted in a crippling of the web at the end of the beam at loads below the capacity of the connection, confirming the theory of the interdependence of seat and beam web.

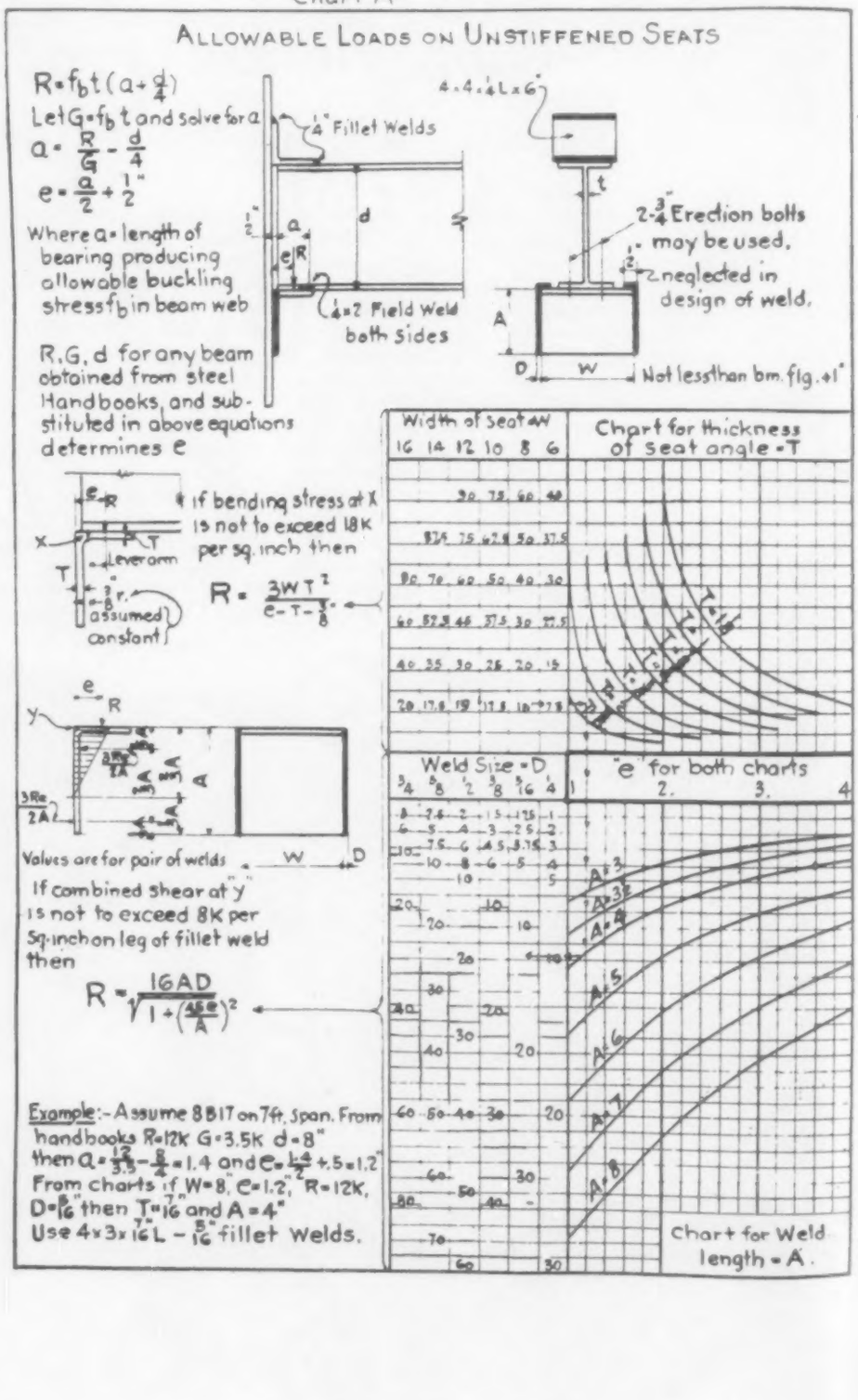
Listed in Table 2*a* are those specimens in each group of tests, whose proportions are most in accord with the theory of a balanced design. The column heads are the same as those used in Table 2 and column 13 has been added to show the ratio of strength of test welds to design welds. Since the test values represent yield points and the design values represent allowable loads, an average ratio of two to one confirms the adequacy of the design method.

There was one point of disagreement between the writer's theory and the test results. It was found the critical section was in the curved portion of the fillet. Applying the design method of the Report to the seats in Table 2*a* shows stresses at the critical section to vary from 20,000 to 33,000 lb. per square inch. Most designers would not consider such local concentration of stress to be objectionable since local deformation will relieve the stress without materially affecting the detail or the structure.

The determination of the stress at the edge of the fillet is much simpler than the method of the Report for determining the stress at the critical section. It is sufficiently accurate to use the method of the Chart, but the designer should know that a greater stress than 18,000 lb. per sq. in. at the assumed section indicates a stress above the yield point at the critical section. He should, therefore, not design knowingly for a stress greater than 18,000 lb. per sq. in. at the edge of the fillet.

The writer has developed design methods for stiffened seats. The design of the material presents no great difficulty, but the design of the welds is affected by the question whether or not the welds carry all the moment. If the welds carry the moment the neutral axis is at the

Chart A


ALLOWABLE LOADS ON UNSTIFFENED SEATS
R = f_b t (a + d/4)
Let G = f_b t and solve for a
a = R/G - d/4
e = a/2 + 1/2"
Where a = length of bearing producing allowable buckling stress f_b in beam web
R, G, d for any beam obtained from steel Handbooks, and substituted in above equations determines e
4 - 4 - 1/4 L x 6"
1/4" Fillet Welds
1/4 x 2 Field Weld both Sides
2-3/4" Erection bolts may be used, neglected in design of weld.
Not less than bm. flg. +1"
If bending stress at X is not to exceed 18K per sq. inch then
R = 3WT^2 / (e - T - 3/8)
Lever arm
3/8 r. assumed constant
Values are for pair of welds
If combined shear at "y" is not to exceed 8K per sq. inch on leg of fillet weld then
R = 16AD / sqrt(1 + (4.5e/A)^2)
Width of Seat = W
Chart for thickness of seat angle = T
Weld Size = D
"e" for both charts
Chart for Weld length = A.
Example:- Assume 8 B 17 on 7ft. span. From handbooks R=12K G=3.5K d=8"
then a = 1.2/3.5 - 8/4 = 1.4 and e = 1.4/2 + .5 = 1.2"
From charts if W=8" e=1.2" R=12K,
D=8/16" then T=7/16" and A=4"
Use 4 x 3 x 7/16 L - 5/16" fillet Welds.

center of gravity of the welds. If the parts are so designed, or the assembly is so made that bearing between the stiffener and the column is assured, then the position of the neutral axis depends on the relative stiffness of the various parts, particularly the dimensions of the stiffening web.

Without confirming data it is necessary to base the design on the neutral axis being located at the center of gravity of the welds, resulting in an excess of welding, which may be considerable on a deep connection. It is recommended that the American Bureau of Welding develop data upon which to base the design of stiffened seats.

Table 2a

Specimen No.	Size of Angles Inches	Fillet Size In.	Lever Arm	Scaling of Weld	Safe Load on Weld from Chart A	Ratio (7) to (10)
(1)	(2)	(3)	(5)	(7)	(10)	(13)
A443-1	4 x 4 x 1/2 x 8″	5/8	1.2	28,550	14,000	2.1
A444-1	"	1/2	"	32,000	19,000	1.7
A654-1	6 x 4 x 5/8 x 8″	1/2	"	60,550	36,000	1.7
A655-1	"	5/8	"	84,500	45,000	1.9
A884-2	8 x 4 x 1 x 8″	1/2	2	84,000	38,000	2.2
A444-c1	4 x 4 x 1/2 x 8″	1/2	1.2	43,000	19,000	2.3
						Av. 2.0

Table 2—Test Results of Series A Specimens

Specimen No.	Size of Angles In.	Weld Data Fillet Size In.	Weld Data Total length In.	Lever Arm at Failure In.	Load per Angle (Lb.) Scaling of Fillet of Angle	Scaling at Top End of Weld	Crack in Top End of Weld	Final Load	Safe Load from Chart A Weld	Safe Load from Chart A Angle	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A443-1	4 x 4 x 1/2 x 8″	5/8	8	1.2	29,950	28,550	29,325	30,430	14,000	19,000	Fair design
2	4 x 4 x 1/2 x 8″	5/8	8	2.0	16,800	21,000	22,225	31,250	10,000	5,000	" "
3	4 x 4 x 1/2 x 8″	5/8	8	3.0	10,400	12,350	13,470	13,470	7,000	4,000	" "
A444-1	4 x 4 x 1/2 x 8″	1/2	8	1.2	....	32,000	39,000	39,380	19,000	19,000	Well balanced design
2	4 x 4 x 1/2 x 8″	1/2	8	2.0	18,850	18,500	24,000	24,000	13,000	5,000	Poorly balanced design
3	4 x 4 x 1/2 x 8″	1/2	8	3.0	10,100	10,000	11,250	13,840	19,000	4,000	" " "
A463-1	4 x 4 x 3/4 x 8″	5/8	8	1.2	71,000	89,500	100,000	112,250	14,000	b	" " "
A464-1	4 x 4 x 3/4 x 8″	1/2	8	1.2	73,000	91,000	101,000	133,835	17,000	b	" " "
A466-1	4 x 4 x 3/4 x 8″	5/8	8	1.2	67,500	116,250	176,500	185,500	28,000	b	" " "
A643-1	6 x 4 x 1/2 x 8″	5/8	12	1.2	....	33,800	38,550	41,650	27,000	19,000	" " "
A644-1	6 x 4 x 1/2 x 8″	1/2	12	1.2	37,000	40,500	46,000	67,305	36,000	19,000	" " "
X-1	6 x 4 x 1/2 x 8″	1/2	12	1.2	22,250	40,500	44,150	67,500	36,000	19,000	" " "
Y-1	6 x 4 x 1/2 x 8″	1/2	12	1.2	25,800	40,800	43,700	78,000	36,000	19,000	" " "
A654-1	6 x 4 x 5/8 x 8″	1/2	12	1.2	53,675	60,550	74,700	98,300	36,000	45,000	Fair design
A655-1	6 x 4 x 5/8 x 8″	5/8	12	1.2	57,000	84,500	102,000	116,000	45,000	45,000	Well balanced design
A664-1	6 x 4 x 3/4 x 8″	1/2	12	1.2	100,000	100,500	136,300	183,200	36,000	b	Poorly balanced design
A843-1	8 x 4 x 1/2 x 8″	5/8	16	1.2	49,000	53,000	74,350	98,375	41,000	19,000	" " "
A844-1	8 x 4 x 1/2 x 8″	1/2	16	1.2	53,000	63,000	74,030	82,050	53,000	19,000	" " "
A864-1	8 x 4 x 3/4 x 8″	1/2	16	1.2	87,250	112,500	132,000	174,100	53,000	b	" " "
A884-1	8 x 4 x 1 x 8″	1/2	16	1.2	137,500	145,000	164,500	204,000	53,000	b	" " "
2	8 x 4 x 1 x 8″	1/2	16	2.0	55,000	84,000	120,500	140,150	43,000	38,000	Well balanced design
3	8 x 4 x 1 x 8″	1/2	16	3.0	36,150	48,000	51,450	63,175	33,000	14,000	Poorly balanced design
A886-1	8 x 4 x 1 x 8″	5/8	16	1.2	137,500	145,000	170,000	230,900	83,000	b	" " "
A444a-1	4 x 4 x 1/2 x 8″	1/2	4	1.2	....	35,900	45,800	52,230	a	19,000	" " "
A444C-1	4 x 4 x 1/2 x 8″	1/2	8	1.2	37,000	43,500	75,000	75,000	19,000	19,000	Well balanced design
A644C-1	6 x 4 x 1/2 x 8″	1/2	12	1.2	37,000	46,300	54,150	81,000	36,000	19,000	Poorly balanced design
A644D-1	6 x 4 x 1/2 x 8″	1/2	12	1.2	35,100	38,000	52,500	69,000	36,000	19,000	" " "

a—Weld not full length of vertical leg—Unusual design.
b—Not within curves on Chart A—Not a flexible seat.

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NEW PUBLICATIONS

Size Card for Sheared and Universal Rolled Plates and Heavy Plates, including sizes rolled on the Lukens 206-in. plate rolling mill. Lukens Steel Company, Coatesville, Pa.

WELDING SOCIETY ACTIVITIES
AND RELATED EVENTS

Amendments to By-Laws of American Welding Society

On March 19, 1935, proposed amendments to the By-Laws were submitted to the membership by letter ballot. Members are allowed sixty days in which to vote and if not rejected by 20% of voting membership at the end of this time, the amendments are automatically adopted. In accordance with the letter ballot the following amendments to the By-Laws are now in force.

Article 1. Sec. 2

"Sustaining Members" being individuals delegated by corporations, firms, partnerships, etc., interested in the science and art of welding, with full rights of membership.

Annual Dues.....$100.00

"Members" being individuals not less than 23 years of age who shall have been for at least three years engaged in work having a direct bearing on the art and science of welding and shall have made some contribution to the science and art of welding. Members in good standing of any major engineering society are also eligible.

Annual Dues.....$15.00

"Associate Members" being individuals interested in the science and art of welding with right to vote but not to hold office except in Sections as may be provided for by the By-Laws of the Section.

Annual Dues.....$10.00

"Operating Members" residing in the United States, Canada and Mexico, who, by occupation, are operators of welding or cutting equipment, without the right to vote or to hold office excepting in Sections as may be provided for by the By-Laws of the Section.

Annual Dues.....$5.00

"Operating Members" residing outside of the United States, Canada and Mexico, who, by occupation, are operators of welding or cutting equipment, without the right to vote or to hold office excepting in Sections as may be provided for by the By-Laws of the Section.

Annual Dues.....$10.00

"Student Members" being individuals who are actually in attendance at any one of the recognized colleges and approved trade schools, without the right to vote or to hold office excepting in Sections as may be provided for by the By-Laws of the Section. At the termination of fiscal year of status as a student, affiliation as "Student Member" shall cease.

Annual Dues.....$2.50

Article II. Sec. 1

The Annual Dues shall be as follows:

"Sustaining Members"	$100.00
"Members"	15.00
"Associate"	10.00
"Operating Members" (resident)	5.00
"Operating Members" (foreign)	10.00
"Honorary Members" (there shall be no annual dues)	
"Student Members"	2.50

Article III. Sec. 3

The AMERICAN WELDING SOCIETY will return to each Section fifty per cent of the first $250 received in dues during the calendar year, from members in the Section (except from Student members) and 25% of the remainder.

Correction to Article Published in the April Issue of the Journal

The article "Metallurgical Data on Fusion Weld Joints," by A. J. Moses, published in the April issue of the JOURNAL, was compiled from data furnished by various members of the Class One Welding Association. In publishing this article, it is regretted that through a misunderstanding certain credits in connection with this valuable assistance were incorrectly given. Dr. T. McLean Jasper has called attention to an error in attributing to him a number of photomicrographs which were in fact prepared by Dr. Hoyt, of the A. O. Smith Corporation laboratories. Those concerned were Figs. Nos. 5, 15, 16, 18, 19, 20, 27, 28, 29, 30, 31, 51, 53, 54 and 59. Also, Figs.

17 and 22 were furnished by the Hedges-Walsh-Weidner laboratories, and not by Drs. Hoyt and Jasper as published.

Kansas Welding Conference

The School of Engineering and Architecture of the University of Kansas announces that the first welding conference will be held at the School of Engineering, Marvin Hall, Lawrence, Kansas, June 27 and 28, 1935—day and evening sessions. This conference will be of particular interest to designing engineers, superintendents, foremen and inspectors of welded structures. The subjects covered by well known and prominent engineers will embrace the design and technique of the fabrication of welded joints.

An invitation is extended by the University to all those interested in this subject to attend this conference. Requests for further information may be addressed to Alfred H. Sluss, Professor of Mechanical Engineering and Superintendent of Fowler Shops, University of Kansas.

New Member Board of Directors

G. Donald Spackman, who was recently elected a Director of the AMERICAN WELDING SOCIETY, is President of Lukenweld, Inc., division of Lukens Steel Company, Coatesville, Pa.

Mr. Spackman was born on June 29, 1895, at Coatesville, and attended the Coatesville High School and Swarthmore College, graduating from the latter in 1917 with the degree of Bachelor of Arts. His Mechanical Engineering degree was awarded in 1924 by Swarthmore.

In the summer of 1919, Mr. Spackman joined Lukens Steel Company, serving in the Mechanical Department and handling steam, hydraulic and combustion problems. In December of 1920, he was appointed Fuel Engineer for the Company, serving in that capacity until August 1925 when he was appointed Superintendent of the Flanging Department.

In August 1929, he was appointed Assistant General Superintendent of Lukens Steel Company. When the Lukenweld division was formed in May 1930 for the design and fabrication of welded steel structures for machinery and equipment service, Mr. Spackman was elected President of Lukenweld, in which capacity he still serves.

He is a member of the Union League of Philadelphia, Racquet Club of Philadelphia, member of the American Society of Mechanical Engineers and the AMERICAN WELDING SOCIETY. He enjoys golf and hunting, and is also interested in photography. He operates Hill Farm, a 300-acre dairy farm at Coatesville, with 70 head of pure bred Jersey cows.

Mr. Spackman is also Chairman of the AMERICAN WELDING SOCIETY'S Committee for the formulation of a tentative code for fusion welding and flame-cutting in machinery construction, which code was recently approved by the Society's Board of Directors.

Turner C. Smith

Turner C. Smith was elected as Divisional Vice-President of the AMERICAN WELDING SOCIETY for the Pacific Coast.

Mr. Smith is a designing engineer for the General Petroleum Corporation of California, Pacific Coast subsidiary of the Socony-Vacuum Oil Company, Inc. His speciality is the design of structures, pressure vessels, tankage and pipe lines.

Mr. Smith has been especially interested in pressure vessel safety problems as a member of the technical advisory committee to the California Industrial Accident Commission in the preparation of its Tentative Unfired Pressure Vessel Safety Orders. He has served on engineering sub-committees of the American Petroleum Institute, dealing with pressure vessel design and riveted tank standards.

He is a past-chairman and a member of the executive committee of the Los Angeles chapter of the AMERICAN WELDING SOCIETY.

Errata

In the May issue of the JOURNAL supplement, page 8, the personnel of the Committee on Use of Welded Steel Parts for Machinery Construction was erroneously reported as including H. Thompson, General Electric Company. The correct name should be "Malcolm Thomson," General Electric Company.

International Competition for the Development of Uses of Calcium Carbide and Acetylene

French manufacturers of calcium carbide in conjunction with the International Syndicate for Calcium Carbide at Geneva, have organized an international competition open to inventors, technicians and laymen of all countries to stimulate and recompense them for studies, publications and research work dealing with new uses, or uses already known, having potentialities for the increased use of calcium carbide, acetylene or oxyacetylene welding, with the exception that the production of synthetic chemicals from an acetylene base are not included.

The first competition was closed on September 30, 1934. 50,000 francs were available for distribution as prices by the competition jury. It was planned to divide the same into four prizes, one of 25,000 francs, one of 15,000 francs and two of 5000 francs each

A jury has recently decided that no one of the papers submitted was of sufficient value to warrant the 50,000 franc prize. The jury awarded a special prize of 3000 francs to Mr. A. de Grey of Paris for his paper on the "Use of Calcium Carbide in Low Temperature Distillation," and a 2000 franc prize to Mr. V. Schobbens of Anvers for his paper on the "Use of Acetylene as Fuel for Automobile Motors through the Employment of a Mixing Carburetor."

It was decided that the contest will be reopened and will run until March 1936 under the same general rules as the previous contest. Further information regarding the competition may be obtained from the General Secretary at the Central Office for Acetylene and Autogenous Welding, 32 Boulevard de la Chapelle, Paris, or Miss M. M. Kelly, American Welding Society, 29 West 39th Street, New York, N. Y.

Fundamental Welding Researches

EDITOR'S NOTE: *It is proposed to publish, from time to time, in the* JOURNAL, *brief progress reports of the investigations in Fundamental Research in Welding. While most of these items will relate to the work of the Fundamental Research Committee and the Structural Steel Welding Committee of the American Bureau of Welding, nevertheless, all investigators are encouraged to give the editor news items of this nature which may be included in this column.*

The Quality of Steel Most Suitable for Arc Welding

By G. E. Doan†

The welding of steel involves such a multitude of variables that development in the fabrication of this most important metal has necessarily been slow, wasteful and in many instances, discouraging. To secure a firm foundation for advancement, it is necessary to reduce these variables to one or two which can be controlled in each experiment. To this end an extensive program of investigation is being carried out at Lehigh University in the study of arcs and arc welds of pure iron; that is, of steel from which the impurities and alloys have been removed. Both the electrode and the work piece are of this pure metal. To prevent contamination of the weld by the oxygen and nitrogen of the air, the welding is done in a non-participating gas—highly purified argon. The welding is done by

† Lehigh University, Department of Metallurgical Engineering.

automatic feeds in two directions. The pressure is maintained at one atmosphere.

For comparison with these pure iron welds, similar welds are made in air. Also ordinary steel welds are made in argon and in air to supply a standard background for interpreting the results obtained with pure iron. These studies are sponsored by the Engineering Foundation of New York City.

When these welds with pure iron are completed, then one element at a time will be added to the iron, such as carbon, or silicon, or phosphorus, and the tests repeated. In this way it will be possible to determine what elements in steel favor and what elements injure its welding properties, and how much of each is permissible. Various welding atmospheres other than argon and air will be used.

The tests with pure iron in argon and in air have been completed as have also those of steel in argon and in air. The physical, chemical and metallurgical properties of these welds have been determined and will serve as basic data for all of the more complicated commercial weld properties. The reports will be published soon.

Problems in Physics

In the investigations of welding done with pure iron in inert atmospheres, observations of a totally different arcing phenomenon from that occurring in air has been found. The mode of globule transfer is different, as is also the matter of crater formation and penetration. These reports are being published.

Welds will be made in various atmospheres to determine the nature of the welding arc discharge under these conditions.

EMPLOYMENT SERVICE BULLETIN

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V-61. Welding Service Man Wanted. Traveling required out of New York headquarters. Applicants should have had at least a high school education. Some correspondence will be required. Work is purely service and not sales. Desired qualifications include good personality; ability to discuss welding problems with and to work on them in the shop with shop men; both practical and technical; intimate familiarity with all types of welding of the strong, corrosion resistant alloys, and a thorough knowledge of fabrication of chemical plant or other heavy equipment. Application should include details of experience, salary desired and references.

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SECTION ACTIVITIES

BALTIMORE

Plans are under way for several interesting meetings in the fall.

BOSTON

During the past twelve months preceding April 1, 1935, the Boston Section has held eleven meetings, and in this series the following subjects were included in the programs.

Oxyacetylene Welding and Cutting.
"Shot Welding" as Applied to Streamline Trains.
Fusion Welding of Pressure Vessels.
A.C. Arc Welding.
Photoelastic Studies of Stresses in Welds.
X-ray Examination of Welds.
Activities of the American Bureau of Welding.

Four of the meetings have been joint meetings with the Boston Sections of other Societies, and four of the meetings have consisted of inspection trips to various plants to see actual welding procedures and results.

Motion pictures, lantern slides and actual demonstrations have been used in the meetings so that those in attendance were able to obtain a maximum of benefit from the subjects offered.

For the eleven meetings of this series, there has been an attendance of about 2131, or an average attendance per meeting of 194.

CHICAGO

The regular monthly meeting of the Chicago Section was held on May 24th at the Sherman Hotel. Mr. Harold Verson, Chief Engineer, The Allsteed Press Co., Inc., spoke on "Economical Welding Procedure in the Shop." Mr. A. L. Wilson, Mississippi Valley Structural Steel Company spoke on "Discussion of Warpage Due to Welding." A motion picture "The Story of Steel" was also shown.

CLEVELAND

The regular meeting of this Section was held May 8th at the Cleveland Engineering Society, Hanna Building, with an attendance of over one hundred. Mr. Chas. H. Jennings of The Westinghouse Electric & Mfg. Company of Pittsburgh gave a very interesting paper on "Arc Welding Cast Steel and Cast Iron" with the aid of illustrative slides.

The Cleveland Section has had a very active season including the regular monthly meetings with an average attendance of about one hundred, members and guests.

DETROIT

At the Annual Meeting of this Section held on Friday, May 3, 1935, the Tellers Committee reported the election of the following officers for 1935–36:

Chairman—W. M. Hayes, Air Reduction Sales Co.
Vice-Chairman—J. D. Tebben, P. R. Mallory Company.
Sec.-Treas.—C. L. Perkins, P. W. Fassler Co.
Member Executive Committees, 1935–37—C. A. Bowlus, Representative, A.T.S.; C. F. Centers, Titus Welding Co.

MILWAUKEE

Meeting of this Section was held on May 28th. The speakers were Robert Holt, Chicago Steel & Wire Co., who showed films and talked on Metal Transfer in Welding; H. O. Quartz, Allis-Chalmers Mfg. Co., whose illustrated talk was on "A Practical Discussion of Heavy Welding," and W. Richter of A. O. Smith Corp., spoke on "Measuring Arc Voltages" which was illustrated with slides.

NEW YORK

The regular monthly meeting of the New York Section was held on May 14th. As usual, the meeting was preceded by a meeting of the Executive Committee of the Section at the Engineers Club. Dr. W. N. Mitchell presided at the regular meeting in the evening. H. L. R. Whitney gave a paper on "Corrosion Resisting Steels in the Petroleum, Chemical and Allied Industries," and E. Peremi spoke on "The Use of Stainless Steel in Architectural Work."

The report of the Tellers Committee was presented and the following officers elected:

Chairman—Gilbert D. Fish, Consulting Engineer.
1st Vice-Chairman—C. W. Bryan, Jr., Federal Shipbuilding & Dry Dock Co.
2nd Vice-Chairman—R. W. Boggs, Union Carbide Company.
Sec.-Treas.—A. F. Keogh, Sound Welding Company.
Executive Committee for 3 yrs.—S. S. Scott, E. Vom Steeg, G. N. Bull, J. L. Edwards.
Executive Committee for 2 yrs.—P. W. Swain.

PHILADELPHIA

The Philadelphia Section had an inspection trip on May 17th to the South Philadelphia Plant of the Westinghouse Electric & Mfg. Co. with about 25 attending. This was held in place of the usual meeting. The following is a list of subjects of meetings to be held during the season 1935–36.

September 16th—Management and Profits in Welding
October 21st—A. C. Welding

Other subjects to be covered during balance of season:

Welding of Non-Ferrous Metals
Automatic Welding and Cutting
Welding of Alloy Steels
Structural Welding
Fatigue and Impact Tests
Welding in Shipbuilding

PITTSBURGH

At a special meeting of the Pittsburgh Section held in the Conference Room of the William Penn Hotel, April 24, 1935, the following were re-elected to serve through the 1935-36 season:

Chairman—E. J. W. Egger, Linde Air Products Co.
Vice-Chairman—Marshall Williams, American Bridge Co.
Secretary-Treasurer—J. F. Minnotte, Minnotte Bros. Co.
Representative on Board of Directors—W. W. Reddie, Westinghouse Electric & Mfg. Co.
Representative on By-Law Committee—E. J. W. Egger.
Executive Committee—The above officers and F. M. Bernard, G. W. Petrie, H. G. Marsh, J. A. Warfel, J. A. Snyder.

It was also voted that Chairman Egger appoint both a Program and a Membership Committee to assist with the work of bringing up the standard of regular meetings and to increase the membership in the Section.

Following the election of officers the questionnaire sent out by Dr. D. S. Jacobus was discussed at some length. A report on the discussions and recommendations will be made shortly.

No further meetings will be held until early Fall.

SAN FRANCISCO

The May meeting of the San Francisco Section was held on the 24th. After the affairs of the Section were discussed the meeting was turned over to Professor Ward who presented a very interesting talk on "The Prediction of Behavior in Welded Construction." The talk was illustrated with slides.

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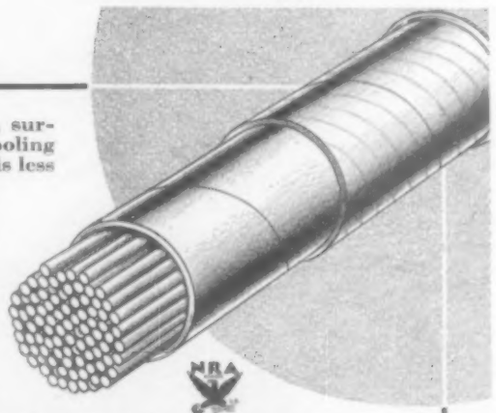

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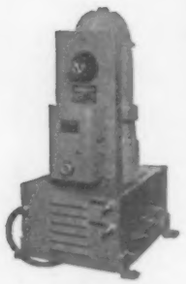

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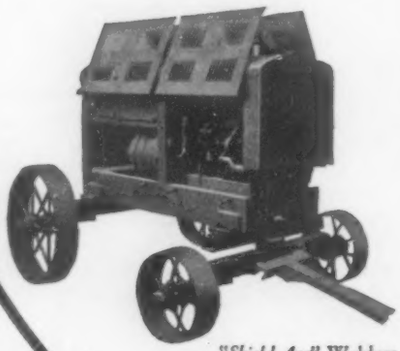

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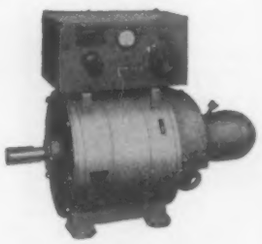

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